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# THE OPTICAL TRACKING OF ARTIFICIAL EARTH SATELLITES

FRED L. WHIPPLE

Director, Smithsonian Astrophysical Observatory, and Professor of Astronomy, Harvard University

(*Read April 25, 1958*)

MANKIND'S curiosity in exploring the unknown and his ability to use the accumulated experience and knowledge of the race have resulted in his creation of nine astronomical bodies in the course of the past seven months. Five artificial satellites have been put into orbit about the earth and three of these involved additional pieces of equipment that have constituted independent satellites. The fact that the lifetimes of these various artificial satellites are relatively short compared to the lifetimes of natural satellites does not detract from their astronomical significance or from the intellectual and technological achievement that they represent. All satellites, whether natural or artificial, are temporary in nature, if one chooses a sufficiently long time scale. Man-made satellites have now become so numerous that the people most intimately connected with the programs are beginning to have difficulty in segregating and recalling the individual characteristics of each one. Hence, for the convenience of both the writer and the reader, Dr. G. F. Schilling has kindly prepared table 1 listing the major basic information concerning the identification, nature, initial orbit, and survival characteristics of these various satellites. Identification is by year, in the order of launching according to the Greek alphabet. When more than one component of a launching is optically detectable the components are identified by Arabic numerals following the Greek letter, in order of decreasing optical brightness. Other entries of table 1 are self-explanatory or are described by subscripts.

The orbital elements of artificial satellites are subject to fairly rapid and major changes arising from the earth's deviation from sphericity and from the effect of atmospheric drag. The major effect of the earth's equatorial bulge is to produce a regression of the orbital nodes, the intersection of the equatorial and orbital planes, in a westerly direction for eastward-moving satellites such as now are aloft. The rate depends upon the orbital inclination and physical dimensions. The direction from the center of the earth to minimum distance, perigee, moves forward (eastwardly) for inclinations below about 63° and retrograde (westerly) for greater inclinations. The nature of these motions is indicated in figure 1 based upon calculations by L. E. Cunningham.[1] Various periodic effects are superimposed upon these secular changes but the equatorial bulge produces no secular terms in the semi-major axis or eccentricity of a satellite orbit.

The effect of the earth's atmosphere is to reduce the angular momentum of a satellite, the physical resistance occurring mostly in the neighborhood of the perigee because of the exponential type decrease of atmosphere with altitude. As a consequence the maximum, or apogee, distance of the satellite decreases more rapidly than the perigee, which remains fairly constant until the eccentricity has become rather small. Typical changes of apogee and perigee [2] are illustrated in figure 2 for an arbitrary time-scale. Hence measurements of the orbital elements of satellites can give direct information concerning the distribution of air density at high altitudes, and the dynamical flattening of the earth, or the extent of equatorial bulge.

The artificial earth satellites have been put into orbit as a part of the program of the International Geophysical Year. Both radio and optical tracking have been conducted on an international basis. The U. S. National Committee of the International Geophysical Year, as a committee of the National Academy of Sciences and with the financial assistance of the National Science Foundation, has assigned to the Smithsonian Astrophysical Observatory the task of optically tracking the artificial earth satellites. The optical tracking program is under the immediate supervision of J.

[1] Cunningham, L. E., The motion of a nearby satellite with highly inclined orbit. Presented at the meeting of the American Astronomical Society, Berkeley, California, August 1956.

[2] Davis, R. J., F. L. Whipple, and J. B. Zirker, The orbit of a small earth satellite. In *Scientific Uses of Earth Satellites*, edited by J. A. Van Allen, Ann Arbor, Univ. of Michigan, 1956.

TABLE 1

TABLE OF ARTIFICIAL SATELLITE PARAMETERS
(Prepared by Dr. G. F. Schilling)

| Parameters | 1957 α1 (Carrier rocket) | 1957 α2 (Sputnik I) | 1957 α3 (Nose-cone?) | 1957 β1 (Sputnik II) | 1957 β2 (Nose-cone?) | 1958 α (Explorer I) | 1958 β1 (Carrier rocket) | 1958 β2 (Vanguard I) | 1958 γ (Explorer III) |
|---|---|---|---|---|---|---|---|---|---|
| Launching date (U.T.) | 4 Oct. | 4 Oct. | 4 Oct. | 3 Nov. | 3 Nov. | 1 Feb. | 17 Mar. | 17 Mar. | 26 March |
| Launching time (U.T.) | ? | = | = | 04 40? | = | 03 48 | 12 16 | = | 17 38 |
| Injection time (U.T.) | ? | ? | ? | ? | ? | 03 55 | 12 26 | = | 17 45 |
| Initial period (min.) | 96.2 | 96.2 | = | 103.7 | = | 114.95* | 134.29* | 134.29* | 115.91* |
| Initial apogee (km.) | 950 | 950 | = | 1,670 | = | 2,540 | 3,965 | 3,965 | 2,800 |
| Initial perigee (km.) | 225 | 225 | = | 240 | = | 368 | 652 | 652 | 188 |
| Inclination (°) | 65.3° | 65.3° | = | 65.4° | — | 33.14° | 34.30° | 34.30° | 33.5° |
| Eccentricity | 0.051 | 0.051 | = | 0.0876 | = | 0.139 | 0.191 | 0.191 | 0.166 |
| Length (cm.) | ? | 58 | ? | ? | ? | 200 | 145 | 16.4 | 200 |
| Diameter (cm.) | ? | 58 | ? | ? | ? | 15.3 | 46 | 16.4 | 15.3 |
| Weight (kg.) | (2,690)? | 83.6 | ? | (3,200)? | ? | 14 | 23 | 1.47 | 14.1 |
| Payload weight (kg.) | — | ? | — | 508.3 | — | 5 | none | (1.0) | 5? |
| Radio transmission (mc.) | — | 40.002 | — | 40.002 | — | 108.00 FM | none | 108.00 | 108.00 |
| (mw.) | — | 1,000 | — | ? | — | 10 | — | 10 | 10 |
| (mc.) | — | 40.005 | — | 40.005 | — | 108.03 AM | none | 108.03 | 108.03 |
| (mw.) | — | 1,000 | — | ? | — | 50 | — | 5 | 50 |
| Battery lifetime (days) | — | 21 | — | 7 | — | 60 and 11 | — | ? | 60 |
| Satellite lifetime (days) | 58 | 92 | ? | 161 | ? | (3–5 years) | (many years) | (many years) | (months) |
| Effective mass-area ratio (gm./cm.²) | (14.5)? | (24.1)** | ? | (17.2)? | ? | 5.5** | 3.8 | 3.96** | 5.6 |
| Scientific experiments carried | none | *a*, *b* | none | *a*, *b*, *c*, *d*, *e* | none | *a*, *b*, *c* | none | *a* | geophysical *a*, *b*, *c* |

* Anomalistic period.
** Antenna drag effects taken into account.
(Parentheses denote estimated value. Equal signs denote values expected to be equal to those of the other components from a single launching; given in preceding column.)
Experiments: (*a*) Satellite Temperatures, (*b*) Meteors, (*c*) Cosmic Rays, (*d*) Solar Radiation, and (*e*) Biological.

Allen Hynek. The program was started in 1956 and is divided into two major sections: (*a*) the Volunteer MOONWATCH Program and (*b*) the Precision Photographic Program.

The MOONWATCH observers utilize small monocular telescopes, usually of aperture of 50 mm. with a magnifying power of 6, so aligned as to form an optical fence along the local meridian,

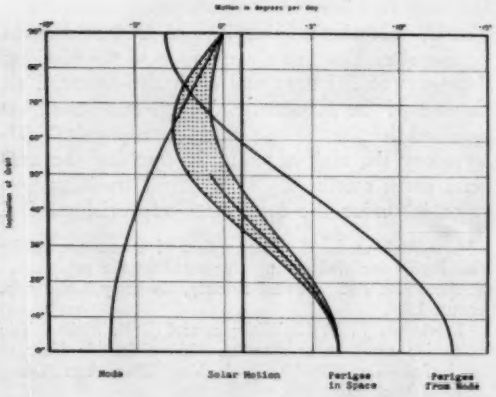


FIG. 1. Secular changes in the orbits of near-earth satellites.

or in some cases at other angles for best observations of satellites of high inclinations (fig. 3). The precision photographic system uses astronomical cameras of 20-inch aperture and 20-inch focal length, which utilize strip film of 5° by 30°. Twelve stations are planned, distributed around the earth between latitudes 37°N and 32°S, and should be in full operation by June, 1958. Karl G. Henize supervises the photographic program.

Project Vanguard, under the direction of the U. S. Naval Research Laboratory, bears the major responsibility of tracking the IGY satellites by radio signals originating in the satellites. Seven of nine *Minitrack* receiving stations, operated by the U. S. Army, are distributed near the 75th westwardly meridian to constitute a radio fence. A second system of radio tracking, the *Microlock* system, has been developed by the Jet Propulsion Laboratory of Pasadena and shares the responsibility for radio tracking. Various powerful radar telescopes have been successful in tracking the rocket stages of the Russian satellites and have contributed enormously by making observations of their death throes. Particularly important is the great 250-foot radio telescope at the Jodrell Bank Experimental Station in England, the 80-

foot radar of Project Lincoln in Massachusetts and the 60-foot radar of Stanford in California.

Of some 230 volunteer MOONWATCH stations registered in April, 1958, 126 are in the United States. The other stations are operated through their respective National Committees of the International Geophysical Year and include some 70 stations in Japan and a number in Australia and South Africa. Represented are South America, Central America, the East Indies, Canada and other countries. In addition the USSR has organized some 70 MOONWATCH stations following the basic principles of operation and equipment as utilized in the U. S. IGY program. Our program is under the immediate supervision of Leon Campbell, Jr., while Armand Spitz has been responsible for much of the organization.

More than 3,000 observations of the various artificial satellites had been made by 179 of these volunteer MOONWATCH stations by April 1, 1958. The program has thus become much more extensive and even more vital to the satellite tracking program than was originally expected. Planned as a program to "back up" the radio satellite tracking program in case of radio failure, and as an observing system for the later stages of satellites as they finally plummet through the atmosphere, MOONWATCH became the primary tracking network for the huge rocket stages of the USSR satellites after the batteries for the radios were exhausted. The high inclinations of these satellite orbits reduced the observational opportunities for the photographic tracking stations located at lower latitudes, while the early firings of the Russian satellites occurred before the completion of the photographic network.

Although the photographic tracking of the rocket stages of the Russian satellites at distances of only a few hundred miles is relatively simple, the photographic telescopes are designed to track 20-inch spheres to a distance of 2,000 miles. An extremely powerful optical system [3] was designed by James G. Baker and produced by the Perkin-Elmer Corporation. The mechanical system, designed by J. Nunn and constructed by the Boller and Chivens Co., facilitates the following of rapid motions of small satellites from rough prediction data without visual acquisition. Hence the mounting is triaxial (fig. 4) so that the camera can be pointed at any direction in the sky and adjusted to

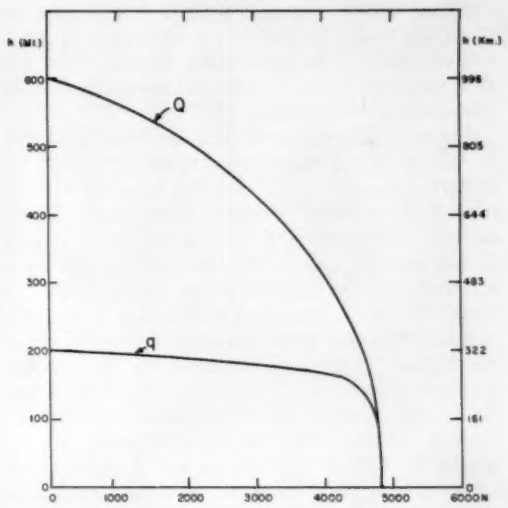


FIG. 2. Variation of perigee and apogee altitude with number of revolutions and with time.

follow at any angular velocity up to 2°/sec. along an arbitrarily chosen great circle. A cycling system makes it possible to photograph a moving satellite as a fixed point on a single photographic frame and, for reference, a fraction of a cycle later to photograph the star background without trailing. Time is maintained at each station by a precision crystal clock built by the Norrman Company. As a rotating shutter periodically occults the trailing star images while the satellite is being photographed, the time of the central occultation is photographed on the film to a readable pre-

FIG. 3. Terre Haute, Indiana, MOONWATCH station.

[3] Henize, K. G., The Baker-Nunn satellite tracking camera. *Sky and Telescope* **16** (3): 3-7, January, 1957.

cision of 0.0001 sec. and a realistic precision of about 0.001 sec., limited by the variations in ionospheric path of the calibrating signals from the time standard WWV of the National Bureau of Standards in Washington, D. C.

Figure 5 illustrates the first image of Explorer I, 1958$\alpha$, photographed on March 18, 1958, by Robert Cameron at the satellite tracking station near Johannesburg, Orange Free State, South Africa. The power of the photographic system is indicated by the fact that the satellite, optically a 6-inch cylinder painted white over a length of about 40 inches, was photographed at a distance of some 700 miles when moving at a rate of 5 miles per second. Figure 6 illustrates the first photograph of Vanguard 1958$\beta$1, the rocket stage, optically equivalent to about a 20-inch perfectly reflecting sphere. This photograph was made on March 19, 1958, by E. Horine and J. Emerson at Organ Pass, New Mexico, who were using a Super Schmidt meteor camera of the Harvard Meteor Program in New Mexico.

The major result obtained to date from the tracking of the first three artificial earth satellites is the determination of atmospheric density at altitudes from 120 to 204 miles, where air densities are too low for determination by sounding rockets. This result is derived by the rate of orbital shrinkage arising from air drag, and indicates air densities at 120 miles some 5 times greater than was anticipated on the basis of previous information. The results obtained by T. E. Sterne, B. Folkart and G. F. Schilling[4] are presented in table 2 in an altitude range from 120 km. to 370 km. At the greater altitudes of table 2 the extrapolation based upon the measures from the first two USSR satellites has been confirmed by T. E. Sterne[5] from observations of Explorer I. The temperatures corresponding to the density measurements depend upon the unknown mean molecular weight of the atmosphere at the altitudes involved, but probably will be higher than expected. Near altitude 390 km. the temperature is 3000° K, to be corrected by the ratio of the actual mean molecular weight of the atmosphere to the assumed value of 29.0 atomic units. Since the orbital shrinkage by atmospheric drag occurs mostly near the perigee, satellites of greater perigee distance will be required to extend these atmospheric density determinations to much greater heights. With its tremendous perigee height of 405 miles

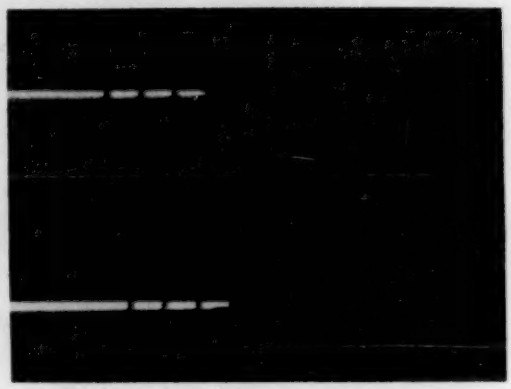

FIG. 5. Photograph of 1958 Alpha (Explorer I) taken on 18 March by Robert Cameron at the Olifantsfontein, South Africa, satellite tracking camera station.

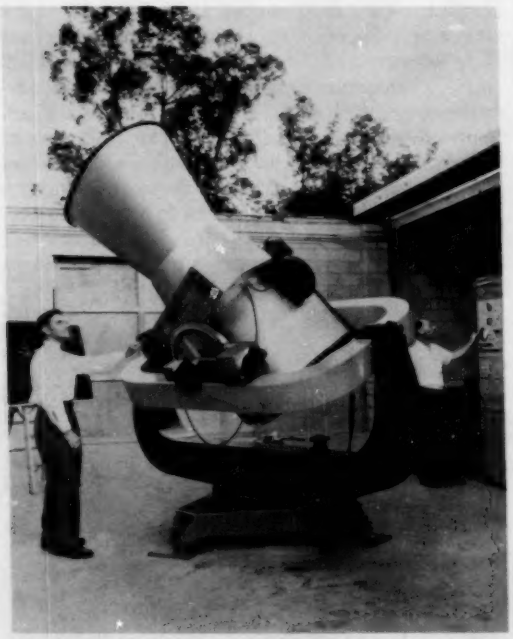

FIG. 4. A Baker-Nunn satellite tracking camera. Dr. Karl G. Henize in foreground.

[4] Sterne, T. E., B. M. Folkart, and G. F. Schilling, An interim model atmosphere fitted to preliminary densities inferred from USSR satellites. Special Report No. 7, IGY Project No. 30.10, Smithsonian Astrophysical Observatory, Cambridge, Mass., December 31, 1957.

[5] Sterne, T. E., The density of the upper atmosphere. Chapter III in Special Report No. 11, IGY Project No. 30.10, Smithsonian Astrophysical Observatory, Cambridge, Mass., March 31, 1958. *Science*, in press.

1958$\beta$2 (Vanguard) will lead to an extension of these data.

Orbital calculations at the Smithsonian Astrophysical Observatory have been carried out by the No. 704 Calculator of the International Business Machines Corporation, a gratuitous loan on their part through the courtesy of the Massachusetts Institute of Technology. The orbital planes of the satellites have moved in the expected sense and amount within the degree of accuracy that the analysis to date has permitted. Thus 1957$\alpha$ and $\beta$ showed a nodal regression of 3.1°/day and 1958$\alpha$ some 4.3°/day. Perigee motions also are consistent with theory. A definitive analysis of the optical data from the two Russian satellites should lead to an improved value of the dynamical oblateness of the earth that produces these perturbations.

The MOONWATCH observations during the demise of USSR satellites 1957$\alpha$1 and 1957$\beta$1, indicate that as these rocket stages enter the lower atmosphere they glow as meteors for about a revolution before their final disintegration and plunge to the earth's surface. The rocket stage, 1957$\alpha$1, appeared as a very bright object in the late afternoon sky to the MOONWATCH team at Los Altos, and over San Diego, California, nearly a revolution before it appeared similarly at two stations in Siberia. Its final breakup was not certainly observed. In the case of 1957$\beta$ the rocket was seen after the end of the twilight period by Canadian and New England MOONWATCH teams as a fourth magnitude glowing object. A few minutes later it disrupted in a great meteor type display over the Barbados Islands but part of the rocket may have persisted beyond. Thus the heavy satellite rocket stage was effectively a meteor for an appreciable fraction of a revolution around the earth.

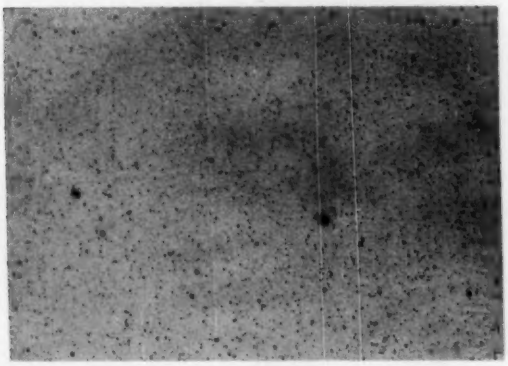

FIG. 6. The first photograph of Satellite 1958 $\beta$1 (3rd stage rocket of Vanguard) was taken on 19 March by E. Horine and J. Emerson at Organ Pass, New Mexico, with a Harvard Super-Schmidt meteor camera.

TABLE 2

AIR DENSITIES

| Geometric height, km. | Air density, gm./cm.$^3$ |
|---|---|
| 120 | $6.91\times10^{-11}$ |
| 130 | $3.01\times10^{-11}$ |
| 140 | $1.49\times10^{-11}$ |
| 150 | $8.07\times10^{-12}$ |
| 160 | $4.70\times10^{-12}$ |
| 170 | $2.89\times10^{-12}$ |
| 180 | $1.87\times10^{-12}$ |
| 190 | $1.25\times10^{-12}$ |
| 200 | $8.63\times10^{-13}$ |
| 210 | $6.04\times10^{-13}$ |
| 220 | $4.47\times10^{-13}$ |
| 230 | $3.32\times10^{-13}$ |
| 240 | $2.51\times10^{-13}$ |
| 250 | $1.93\times10^{-13}$ |
| 260 | $1.51\times10^{-13}$ |
| 270 | $1.19\times10^{-13}$ |
| 280 | $9.51\times10^{-14}$ |
| 290 | $7.68\times10^{-14}$ |
| 300 | $6.27\times10^{-14}$ |
| 310 | $5.16\times10^{-14}$ |
| 320 | $4.29\times10^{-14}$ |
| 330 | $3.58\times10^{-14}$ |
| 340 | $3.02\times10^{-14}$ |
| 350 | $2.55\times10^{-14}$ |
| 360 | $2.18\times10^{-14}$ |
| 370 | $1.87\times10^{-14}$ |

A detailed study of these phenomena will be of interest with regard to the interaction between metallic surfaces and the very high atmosphere both at night and under solar illumination. Of aerodynamic interest is the fact that both rocket stages apparently stopped tumbling and oriented themselves like arrows during their last few revolutions.

The longer range program with the precision photographic cameras will involve extremely precise tracking and computations in which the satellite is effectively a triangulation target for geodetic measures. The tracking cameras should be able to provide positions accurate to about 2 seconds of arc normal to the trail, 10 feet at 200 miles distance, and along the trail to an accuracy of .001 second or approximately 25 feet. Thus the geometrical analysis, coupled with the most precise orbital calculations, should lead to determinations of the relative positions of the stations with respect to the center of the earth to an accuracy of some 30 feet, approximately 10 times the present available precision. Thus the geodetic systems of

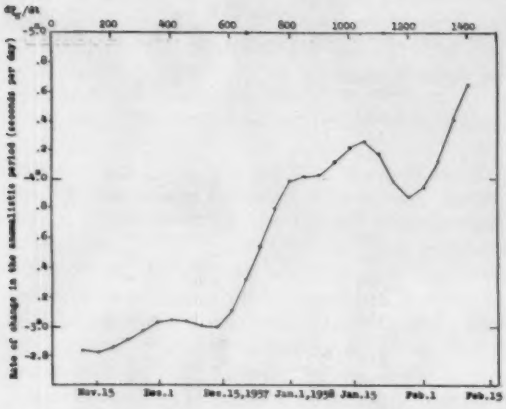


FIG. 7. Rate of change of the anomalistic period as a function of time (1957 $\beta 1$).

the various continents can be interrelated with this high degree of accuracy, the oblateness of the earth derived to this accuracy and a more exhaustive search made for lack of circular symmetry around the equator. In addition the orbital variations will measure gravitational irregularities, or gravitational anomalies, on the earth and determine more precisely the distribution of matter within the earth. These results will derive from a great many precision observations of satellites for which atmospheric drag can be calculated with assurance; in other words, circular satellites, giving a uniform cross section for atmospheric resistance. Figure 7 shows the variations in the change of orbital period for 1957$\beta 1$ as derived by L. G. Jacchia.[6] The elongated object presented a varying frontal area with consequently great irregularities of motion. Predictions for such satellites can be made only a few days in advance and variations in atmospheric density cannot readily be measured. The rocket stage of 1958$\beta$ gives great promise of being extremely valuable for these geodetic purposes because of the great perigee distance. Even though the drag itself may not be predictable with precision, its amount is so small that good results are to be expected from precision observations of the rocket stage. The satellite itself, of course, can scarcely be the object of routine observation by any of the available photographic techniques. A more massive satellite, therefore, in an orbit with a very high perigee is the most desirable for such geodetic investigations and we expect such satellites to be launched in the near future.

[6] Jacchia, L. G., Basic orbital data for satellite 1957 beta one. Special Report No. 9, IGY Project No. 30.10, Smithsonian Astrophysical Observatory, Cambridge, Mass., February 21, 1958.

# THE DIVINE MUSHROOM: PRIMITIVE RELIGION AND HALLUCINATORY AGENTS

**R. GORDON WASSON**

Vice-President, J. P. Morgan & Company, Inc.

(*Read November 16, 1956*)

THE world of wild mushrooms and toadstools is of little interest to most of us, even those of us who are lovers of nature. We all know something about birds and insects and trees. But how often do you fix your gaze on a wild mushroom?

This neglect is a mistake. What a wondrous world do they offer us, in the diversity of their shapes, their colors, their odors, the texture of their skins; yes, above all in the aura of silent mystery that seems to enfold them. Indeed this aura of mystery may explain why they are neglected. My wife and I believe that, anthropologically speaking, for us Anglo-Saxons a tabu hangs over wild mushrooms, a tabu coming down from our remote past and surviving today long after the reason for it has slipped away from men's memories.

For close to thirty years my wife and I have been devoting part of our spare time to studying, not so much the mushrooms themselves, as the attitude toward them of various peoples in Europe and elsewhere. We have arrived at the conviction that the common ignorance and distrust of wild mushrooms are not the fruit of rational behavior. It is a cultural legacy of a remote age when our unlettered ancestors held wild mushrooms in awe as the habitation of demonic powers. There is no time to develop for you our supporting evidence. Instead I shall leap forward to the phase of our inquiry that led your Society to make us a grant in furtherance of our studies.

There exist certain species of wild mushrooms that contain a most potent and mysterious drug—mushrooms which, if you eat them, cause you to see visions, breathtakingly vivid visions in color and motion, visions of almost anything you can imagine except the scenes of your everyday life. These mushrooms confront us with a scientific problem. We must isolate the active agent, determine its molecular structure, synthesize it, and arrive at its properties, and also its uses if any. This scientific problem is as difficult as it is in-

FIG. 1. María Sabina, the Mazatec *curandera*, passing the mushrooms through the smoke of aromatic plants. Photo taken in 1956 by Allan Richardson.

FIG. 2. María Sabina invoking with prayers the divine blessing for the ceremony she is about to undertake. Photo by Allan Richardson.

FIG. 3. Partaking of the divine mushroom: María Sabina and her son at the moment of the holy agape. Photo by Allan Richardson.

viting, and needless to say we are passing it over to those who are qualified to perform it. But the hallucinogenic mushrooms invite our study for another reason. From earliest times they have been worshipped by certain primitive peoples scattered from Mexico to Borneo and Siberia, and we think formerly in Europe too.

The visions that you see when you eat the mushrooms are staggering in their subjective impact. They are no shadowy, uncertain sights. When you see them you are moved to exclaim, if only to yourself, that never in your normal state have you seen things so clearly, so truly. At last you are seeing clearly, not as through a glass darkly. If in that span of ecstatic vision you think of Plato, you will say to yourself that you are seeing the Archetypes, the very Ideas of Plato. You do not lose possession of yourself. You are in a pseudo-schizophrenic state, and you can take notes, and observe yourself, and afterwards you remember everything in detail. Possibly the hallucinations are aural as well as visual. Just as you are seeing things in your mind's eye, so you may hear things in the mind's ear, the music of the spheres accompanying the Ideas of Plato. The emotional effects of the drug are equally interesting. You experience ecstasy. In my case, for the first time the meaning of "ecstasy" came over

FIG. 4. In ecstasy, seeing visions. In the dead of night, in pitch dark, María Sabina's son, caught unexpectedly by flash-light, as his mother is singing to him. The baby is asleep, having taken no mushrooms. The other Indian also is seeing visions. Photo by Allan Richardson.

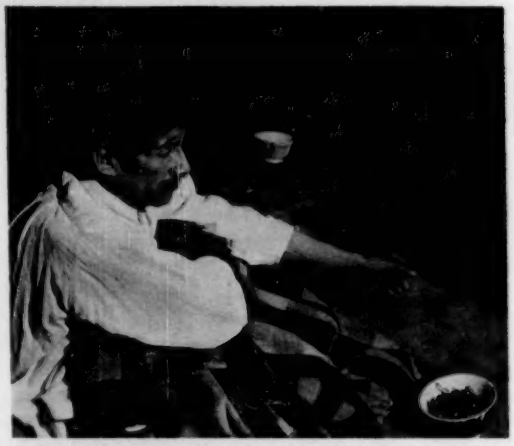

FIG. 5. A Zapotec Indian, a *curandero* of the Sierra Costera, contemplates his bowl of mushrooms. This photo was taken in 1955, by Howard E. Brunson, at San Agustín Loxicha, linguistically far removed from the Mazatec country.

me, no longer as an intellectualized definition, but subjectively. Indeed, you are spellbound by awe, by feelings of wonder and reverence, by an overflowing sense of empathy, of *caritas* towards those who are sharing the mushrooms and the experience with you.

The primitive peoples who worship these mushrooms consider that they open the gates to another plane of existence, to the past and future, to Heaven and God, who then answers truly all grave questions put to him. If we are right in our conjecture that the secret of these mushrooms was discovered by early man, perhaps very early as he was emerging from his bestial past, think

for a moment what their miraculous properties must have meant to him! Our hallucinogenic mushrooms opened to him conceptions and emotions theretofore beyond his reach: horizons beyond his horizons, planes of existence other than the one in which he lived, feelings of awe and reverence, yes perhaps the very idea of a Superior Being. They may have served as a mighty detonator for early man's soul and mind and imagination. It is surprising, we think, that students of early cultures have paid so little attention to the subjective impact on them of hallucinatory agents like these.

On this subject I speak to you not by hearsay but as a witness. On the night of June 29–30, 1955, my friend and photographer Allan Richardson and I ate these mushrooms in the course of a mushroomic communion or agape in a remote circle of Indians in Mexico. So far as the records indicate, we are the first white men of the modern world to have had this experience. We underwent the visual, aural, and emotional effects of the mushrooms. Since then a few other persons, introduced by us, have eaten the mushrooms under similar circumstances. Furthermore, my wife and daughter and I have also eaten them cold turkey, so to speak, by ourselves, even in New York, without the accompaniment of the primitive religious ritual. The effects were in no wise diminished.

# THE CLAIM OF ANTIOCH TO ECCLESIASTICAL JURISDICTION OVER CYPRUS

GLANVILLE DOWNEY

Dumbarton Oaks Research Library

ONE of the best known episodes in the history of both the Patriarchate of Antioch and the island of Cyprus is the protracted struggle over the ecclesiastical status of the island, and it was as the outcome of this contest that Cyprus became autocephalous. A considerable literature has arisen about this subject, and the edifying and spectacular story of the discovery of the body of St. Barnabas, holding on his chest a copy of the Gospel of Matthew written in St. Barnabas' own hand, has become well known. However, none of the published accounts of the whole history (at least so far as the writer has been able to discover) has utilized all of the available material, and it has been found, as a result of a new survey of the texts, that certain features which previous investigators appear to have overlooked prove in fact to be of considerable interest for our understanding of the problem and its history.[1]

In the preserved sources, the question of the supremacy of Antioch first appears in specific form in the correspondence between Alexander, Bishop of Antioch 413–421, and Pope Innocent I, 402–417. Alexander, having established peace within the church at Antioch after a period of internal dissension, was naturally anxious to make sure that the authority of his see was recognized in the provinces which he considered to be under his jurisdiction. Apparently he had tried to secure an acknowledgment of obedience from Cyprus and had not been successful, for we see that among several questions relating to the ecclesiastical jurisdiction of Antioch which Alexander thought it necessary to address to the Pope, one concerned the ordination of the bishops of Cyprus.[2] Alexander wrote with reference to the sixth canon of the Council of Nicaea in 325, which (as may be seen from the opening paragraph of Innocent's reply) Alexander took to guarantee that the bishops of Antioch should, according to their "ancient right," consecrate bishops not only for the province of Coele Syria, in which Antioch was located, but in the whole civil Diocese of the *Oriens*. This would place Cyprus under the ecclesiastical jurisdiction of Antioch, since the civil Diocese of the *Oriens*, whose governor the *comes Orientis* had his headquarters at Antioch,[3] included the province of Cyprus, both at the time when Diocletian set up the dioceses as units of civil administration,[4] and at the time of Alexander and Innocent.[5] Since the *consularis* of Cyprus, the civil governor of the island, was a subordinate in the imperial administration of the *comes Orientis*, Cyprus had the closest possible civil connections with Antioch, and so it would follow—if

[1] The present study was made during the writing of my history of Antioch, which is in progress and will it is hoped soon be published. The most detailed existing account of the problem is that of J. Hackett, *A history of the Orthodox Church of Cyprus*, 13–32, London, Methuen, 1901. Hackett does not, for his purpose, have occasion to examine some of the details which are investigated here. Hackett's conclusions are summarized and adopted by George Hill, *A History of Cyprus* **1**: 273–279, Cambridge, Eng., Cambridge University Press, 1940. A succinct account of the question down to the year 461 is provided by B. J. Kidd, *A history of the Church to A.D. 461* **3**: 175–178, 248–249, Oxford, Clarendon Press, 1922. See also A. Palmieri, Chypre, Église de, *Dictionnaire de théologie catholique* **2**: cols. 2428–2431, and S. Vailhé, Formation de l'église de Chypre, *Échos d'Orient* **13**: 5–10, 1910, whose conclusions are embodied in the article by R. Janin, Chypre, *Dictionnaire d'histoire et de géographie ecclésiastiques* **12**: col. 794.

[2] Alexander's letter is not extant, but its contents may be reconstructed from the reply of the Pope, who in answering Alexander takes pains to state the questions in the form in which they had been put to him (Innocent, *Epistle* XXIV, Migne, *Patrologia Latina*, XX, 547–551).

[3] See G. Downey, *A study of the comites Orientis and the Consulares Syriae*, 7–11, Dissertation, Princeton, 1939.

[4] This is shown by the listing of Cyprus as part of the civil Diocese of the Orient in the provincial list in the *Laterculus Veronensis* **1**: 16 (in *Notitia Dignitatum*, ed. O. Seeck, 247, Berlin, 1876), which shows the status of about the years 304–306 (on the date, see E. Stein, *Geschichte des spätrömischen Reiches* **1**: 102, n. 3, Vienna, Seidel, 1928).

[5] This is indicated by the inclusion of Cyprus as a province governed by a *consularis*, as part of the civil diocese of the Orient, in the *Notitia Dignitatum*, ed. Seeck, Oriens, **1**: 3 and **22**: 48–49. On the date of the *Notitia*, see A. Piganiol, *L'Empire chrétien (325–395)*, x, Paris, Presses Universitaires de France, 1947. Some modern writers on the Cyprus question use incorrect titles in this connection, speaking of the "prefect of Cyprus" and the "Duke of Antioch," etc.

the ecclesiastical territorial division paralleled the civil one—that the metropolitan of Cyprus was the subordinate of the Patriarch of Antioch,[6] and that neither could a metropolitan of Cyprus be consecrated except by a Patriarch of Antioch, nor could bishops be appointed in Cyprus without the knowledge and consent of the Patriarch of Antioch.[7] During the Arian troubles, however, (Alexander claimed), the Cypriotes, fearing the Arian tendencies which prevailed at Antioch, consecrated their own bishops without consulting anyone. Alexander stated that the Cypriotes had continued to act in this way down to his own time.

Innocent, apparently without making any independent investigation, replied, on the basis of Alexander's assertions,[8] that the people of Cyprus must abide by the canons and that the authority of Antioch derived from the fact that Peter was bishop first there and then at Rome.

How much real ground for his claim Alexander had, we cannot be sure, since the extant sources are insufficient to support his claim and there are no reliable texts which indicate that the metropolitans of Cyprus were appointed or approved by the bishops of Antioch in the period before the Arian troubles. In fact the contrary would appear to have been the case, for in the signatures at the Council of Nicaea, Cyprus does not form part of the jurisdiction of Antioch and is not listed among the provinces which belonged to the Diocese of the *Oriens*, but appears in a widely separated position in the list.[9]

What the first occasion was on which Innocent's pronouncement might have been invoked, is not certain. When the Council of Ephesus met in the summer of 431, it was stated by the Cypriote delegation that the three most recent metropolitans of Salamis (Constantia) had not been consecrated by the Patriarch of Antioch, these three being, in chronological order, Epiphanius, Sabinus and Troilus.[10] Epiphanius died in May of 403,[11] that is, well before Alexander of Antioch (413–421) brought up the question of his supremacy with the Pope. The details of Sabinus' career do not appear to be known. Troilus was in office during the episcopate of Theodotus of Antioch (421–428),[12] and died early in 431, before the opening of the Council of Ephesus.[13] Whether Troilus was consecrated as metropolitan before Innocent's pronouncement was made is not mentioned in any extant source. It would seem as though he had been, for when he visited Antioch during the episcopate of Theodotus, on business not connected with the hierarchical question, the clergy and bishop of Antioch, apparently finding in Troilus' visit an excellent opportunity to assert the doctrine which had just received the support of the Pope, tried to force Troilus to acknowledge their superiority. They seem to have had no success, although they thought fit to employ violent means and even, it was said, inflicted blows on the Cypriote bishop.[14]

[6] It is sometimes stated, in modern treatments of the problem, that a parallel existed between the appointment of the *consularis* of Cyprus by the *comes Orientis*, and the consecration of the metropolitan of Cyprus by the Patriarch of Antioch. This is a false analogy, and so far as the present writer knows, it was not invoked in antiquity. The governor of Cyprus was appointed by the emperor (Stein, *op. cit.* **1**: 103), who would never have allowed the *comes Orientis* to become so powerful as to appoint governors of provinces.

[7] The extent of the prerogatives is stated in the first section of Innocent's letter.

[8] Innocent writes: Cyprios sane asseris . . . non tenuisse Nicaenos canones . . . (Migne, *Patrologia Graeca*, XX, 549 A).

[9] E. Honigman, La liste originale des Pères de Nicée, *Byzantion* **14**: 45–48, 1939; R. Devreesse, *Le Patriarcat d'Antioche*, 124–127, Paris, Gabalda, 1945.

[10] E. Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 121.39–41. Some of the scholars who have dealt with the problem (e.g. Vailhé, *op. cit.*, 9; Janin, *op. cit.*, col. 794; Hackett, *op. cit.*, 16) have invented a Cypriote metropolitan named Theodore, whose existence apparently was suggested by a misreading of the reference to Theodotus of Antioch in the opening address of the Cypriote bishops at Ephesus (Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 118.29–30), combined with the mistranslation which appears in the Latin version of this address preserved in the *Collectio Winteriana* (Schwartz, *Acta Conciliorum*, I, 5, pt. 2, p. 357.21, *cf.* apparatus criticus *ad loc.*), aided perhaps by confusion with the name of the *consularis* of Cyprus, Theodorus. The result has been the quite erroneous conclusion that Bishop Troilus died some time before 431 and that he was succeeded by a Theodorus, who was the metropolitan whose death early in 431 precipitated the events at Ephesus (*cf.* Janin's table of bishops, *op. cit.*, col. 809). A careful reading of the opening speech of the Cypriote delegates will show that this is not true; and later in the report of the same session at the council (Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 121.40) Troilus is referred to by name as "he who has just died."

[11] Jülicher, Epiphanios, No. 3, Pauly-Wissowa, *Realencyclopädie* **6**: 193.

[12] Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 118.29–30.

[13] Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 118.35–36. By an oversight, W. Ensslin in his biographical notices of the two bishops named Troilus (Pauly-Wissowa, *Realencyclopädie* **6** A, 616 Nos. 5 and 7), has referred to the second bishop (No. 7, not the metropolitan of Cyprus) a text (Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 121.39) which concerns the metropolitan of Cyprus.

[14] Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 118.28 ff.

The next opportunity for Antioch came when Troilus died early in 431. Bishop John of Antioch must have looked upon the coincidence of Troilus' death at this time as a chance to obtain a ruling at the council which had already been summoned to meet at Ephesus later in the year. In order to make sure that he would have this opportunity, John enlisted the support of Flavius Dionysius, the *magister militum per Orientem*, or commander of the imperial troops in the Diocese of the Orient, who had his headquarters at Antioch. Flavius Dionysius was prevailed upon to issue an order, dated at Antioch, 21 May 431, addressed to Theodorus, the *consularis* or governor of Cyprus, forbidding the consecration of a metropolitan in Cyprus before the forthcoming meeting of the council at Ephesus, and stipulating that if a consecration had taken place before his order reached Cyprus, the bishop who had been elected was to appear at Ephesus to offer explanations.[15] Dionysius also wrote to the clergy of Constantia, the metropolitan see, ordering them to postpone the choice of a successor to Troilus until the council at Ephesus had issued a ruling on the status of Cyprus, and adding the same provision to cover any election which might have taken place before the arrival of his letter; in this stipulation, both the new metropolitan and the other bishops concerned were in such a case to appear at Ephesus.[16] To enforce his orders, Dionysius sent two officers from his headquarters, Maturius and Adelfius.[17] A deacon of the church at Antioch accompanied them.[18]

Reginus was elected metropolitan of Constantia —whether before or after the arrival of Dionysius' instructions is not clear—and proceeded to Ephesus with other Cypriote bishops, in order to claim that Cyprus had always been independent in the matter of episcopal appointments.[19] Reginus first showed his position by making an exceptionally violent attack on Nestorius in a sermon delivered at Ephesus during the meeting of the synod.[20] He then appeared with his colleagues before a session of the council to ask for a decision on the rival pretensions of Antioch and Cyprus. Since John of Antioch was not present at the session at which the Cypriote bishops presented themselves,[21] there was only a one-sided hearing of the case. When questioned by the council as to who had consecrated the last three metropolitans of Cyprus, one of the Cypriote bishops (as has been noted) replied that they had all been orthodox and that they had all been consecrated by the bishops of Cyprus, and that no Antiochene or other bishop had ever had any power of ordination in their province. The council seems to have made no investigation, and there was no opportunity for cross examination or for the presentation of the Antiochene position. Nevertheless, the council's decision—embodied in a resolution, not a canon —was contingent:[22]

> . . . If, as it is asserted in memorials and orally by the religious men who have come before the Council —it has *not* been a continuous ancient custom for the bishop of Antioch to hold ordinations in Cyprus, —the prelates of Cyprus shall enjoy, free from molestation and violence, their right to perform by themselves the ordination of bishops [for their island]. . . .

If John of Antioch had been present at this session, he might or might not have been able to present the claim of Antioch successfully; but it is noteworthy that although the council's decision in favor of Cyprus was made contingent upon the Cypriotes' claim being true, there is no record that the Patriarchate of Antioch ever attempted at any subsequent council to have the declaration of Ephesus reversed.

Moreover, there is one very distinct indication that John was aware of a weakness in the Antiochene claim. John had occasion later to write a letter to Proclus, Patriarch of Constantinople (443–446), in which he listed the provinces which were subject to the ecclesiastical jurisdiction of Antioch, and Cyprus is not included in this list.[23] If John had been anxious to keep up the claim of Antioch, it would seem that he would have made a point of including Cyprus in the list of provinces subject to him.

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[15] Dionysius' order, which includes a penalty of a fine if Theodorus' office does not carry out the instructions, is extant in both the Latin original and a Greek translation, both of which the Cypriotes brought with them to Ephesus (Schwartz, *Acta Conciliorum*, I, 1, pt. 7, pp. 119.30–121.31).

[16] Schwartz, *Acta Conciliorum*, I, 1, pt. 7, pp. 120.37–121.9.

[17] *Ibid.*, 120.8.

[18] *Ibid.*, 119.13.

[19] *Ibid.*, 121.42–45.

[20] Schwartz, *Acta Conciliorum*, I, 1, pt. 2, pp. 70–71.

[21] Kidd, *History of the Church* 3: 248–249.

[22] Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 122.1–22. Only a part of the resolution is reproduced above, in the translation of W. Bright, *The Canons of the First Four General Councils*, ed. 2, 136, Oxford, 1892.

[23] Migne, *Patrologia Graeca*, LXXXIV, 811–812, ch. 197.

One further detail might be indicative of a weakness in John's position, though here we are not really well enough informed to be sure that it is to be interpreted in this way. The Cypriote bishops, in their petition at Ephesus, made it one of their grievances that the order postponing the election of the metropolitan was issued by the *magister militum per Orientem* Dionysius, who, they said, was officially entrusted only with military matters and had nothing to do with ecclesiastical affairs.[24] That something of the same impression prevailed among the members of the council is suggested by the circumstance that their first thought, after the documents of the Cypriote bishops had been read into the record, was that while the documents were "clear," the reason which prompted Dionysius to act was "obscure"; and so, as their first question, the members of the council asked the Cypriote bishops what it was that moved the *magister militum* to send these orders.[25] The Cypriotes' reply—whether correct or not, we cannot be sure—was that Dionysius had acted "at the suggestion" of the bishop of Antioch.[26]

Of course it was plain to everyone that the council, dominated by Cyril, was hostile to Antioch, and all the remarks quoted above were made —and heard—against a background which everyone understood. However, what was said may well mean that such proceedings actually did not fall within Dionysius' duties, and that John of Antioch had enlisted Dionysius' support—and this of course was powerful—because the patriarch preferred not to apply to the proper official, who, we might expect, would be the *comes Orientis*, as the regular superior of the *consularis* of Cyprus. Of course the army was responsible for order and security, and in such a matter, in this region, the *magister militum per Orientem* was the responsible official; but whether he would be authorized to act as he did, in such a case as this, independently (as it seems) of the *comes Orientis*, we cannot be sure. The *magister militum* would seem to have been a religious man, for he was cured by St. Symeon Stylites of what seems to have been a heart attack.[27] We know that he was a friend of Bishop Theodoret of Cyrrhus,[28] who lent his support to John of Antioch in the dispute with Cyril of Alexandria over Nestorius' views,[29] and we also possess a letter of Dionysius addressed to the bishops of Syria in which he enjoins them to bring themselves into communion with John of Antioch or leave their cities.[30] Certainly Dionysius the *magister militum* seems to have been an ally—whether in a personal or an official capacity—of the Antiochene patriarch and his friends; and it is quite possible that it was on purely personal grounds that Dionysius used his powers in these matters, powers which the *comes Orientis* may not have been in a position to dispute.

Antioch did make one more effort, in the reign of Zeno, to establish ecclesiastical control over Cyprus. This attempt was made in 488 by the monophysite Patriarch of Antioch Peter the Fuller. Unfortunately our knowledge of Peter's effort depends upon a hostile source, which is demonstrably inaccurate in some of its historical details, namely the encomium of St. Barnabas written by the monk Alexander of Cyprus in the middle or latter part of the sixth century, several generations after the episode itself.[31] Thus we cannot be sure just how Peter set about his attempt. According to the monk Alexander, who was a Cypriote and was writing his encomium in order to provide evidence for the independence of his island, Peter tried to assert the ecclesiastical supremacy of Antioch, and the Cypriotes rejected his claims because, they said, their church had always been free up to that time, and, in addition, because Peter and the church at Antioch were monophysite, so that the pious and orthodox clergy

[24] Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 119.2–5.

[25] *Ibid.*, 111.10–14.

[26] *Ibid.*, 119.18.

[27] See the Syriac biography of Symeon edited by H. Lietzmann and H. Hilgenfeld, Das Leben des heiligen Symeon Stylites, *Texte und Untersuchungen* **32** (4): 117–118, Leipzig, Hinrichs, 1908. Dionysius was consul in 429 (Lietzmann, *op. cit.*, 246; O. Seeck, Dionysios, Pauly-Wissowa, *Realencyclopädie* **5**: 915), but we do not know the dates of his tenure of the office of *magister militum* beyond the period of the episode under discussion.

[28] Schwartz, *Acta Conciliorum*, I, 1, pt. 7, p. 147.8–12.

[29] Kidd, *History of the Church* **3**: 225, 232 ff.

[30] Migne, *Patrologia Graeca*, LXXXIV, 758–759, ch. 143.

[31] Alexander's encomium, in Greek, is obviously a tendentious document composed to support Cyprus' claim to autocephaly. It is printed in *Acta Sanctorum*, Junii, tome II, 436–452, the account of Peter the Fuller's attempt on Cyprus, and of the discovery of St. Barnabas' remains, being on pp. 441–447. For a criticism of this work, and a summary of the internal evidence which places its composition in the middle or latter part of the sixth century, see R. A. Lipsius, *Die apokryphen Apostelgeschichten und Apostellegenden* **2** (2): 270–304. Braunschweig, 1884. A Latin version of Alexander's encomium is printed in Migne, *Patrologia Graeca*, LXXXVII, pt. 3, where the passage on Peter the Fuller appears at cols. 4099–5104.

of Cyprus could not be in communion with them. Then, according to Alexander, Peter produced a new basis for his claim. Citing neither the sixth Nicene canon which had been quoted at Ephesus, nor the declaration on Cyprus made by the bishops at Ephesus, Peter the Fuller attempted to assert the ecclesiastical control of Antioch over Cyprus simply on the ground that (as related in Acts 11: 19; 13: 4–12; 15: 39) Christianity had been taken to Cyprus from Antioch, which was an apostolic foundation, and that therefore Cyprus should be subject to Antioch. Peter's argument, of course, could have the consequence that the see of Antioch could claim ecclesiastical control over a number of churches, in addition to Cyprus, lying outside the Diocese of the Orient, and it may be difficult to believe that even Peter the Fuller could have hoped that this argument would carry weight. However, St. Barnabas, Cyprus' chief saint, saved the day, according to the well-known story. In a dream, he revealed the location of his tomb, previously unknown, to the bishop of Constantia. The bishop and people, setting out in solemn procession, went to the spot described and found the remains of the saint, with, reposing on his chest, a copy of the Gospel of Matthew written in St. Barnabas' own hand.[32] In the circumstances, this discovery could only be taken to mean that St. Barnabas had intervened and had arbitrated the question, clearly indicating that his decision was in favor of Cyprus.[33] The emperor was readily convinced by this demonstration of the saint's opinion, and the imperial favor was assured when the precious copy of the Gospel of Matthew was presented to Zeno, who arranged to preserve it carefully in the palace at Constantinople. To the emperor and a council which he summoned to consider the matter, the revelation of Barnabas' resting place, and of the copy of the gospel, furnished indisputable proof that Cyprus was as much of an apostolic foundation as Antioch; and the past history of the question being what it was, it followed that Cyprus should be autocephalous.[34] There is no indication why Antioch, with which Barnabas had been so closely associated, had not made an effort to claim the saint's patronage. It is to be noted that a number of the chroniclers who record the discovery of Barnabas' remains, and of the copy of the gospel, state that the autocephaly of the island had its basis in this discovery, and do not mention the pronouncement of the Council of Ephesus.

After this, we do not hear of the subject until, at the Council in Trullo (692), the rights of the Cypriote church were reaffirmed[35] in order to make clear the position which it had been occupying as a church in exile, following the occupation of the island by the Moslems. At some period which cannot now be determined accurately, an unknown forger, attempting to support the claim of Antioch over Cyprus, wrote a false canon, supposed to have been formulated at Nicaea, according to which Cyprus was subject to Antioch in the matter of the consecration of the archbishop of Cyprus. This canon is preserved among the eighty Arabic "canons of Nicaea," which pretend to be translations of lost Greek originals, but are demonstrably falsifications made for various special purposes. This forged canon concerning Antioch and Cyprus must be later than 431, but how much later it was written, we cannot now tell.[36] As has been pointed out, if this canon, now preserved in Arabic, were authentic, it is inconceivable that it should have been overlooked when the subject was considered at Ephesus in 431.

Such is the history in ancient times of this question, which played such an important part in preparing the background of the present situation in Cyprus. It is possible that further evidence may in time come to light, but the main course of the development seems quite clear, and we can hope only that some day some of the details may be further clarified.

[32] In addition to the full description of the discovery of the relics in the encomium of Alexander, brief notices of the event are preserved in several chronicles: Victor Tonn., *ad an.* 488 (in Mommsen, *Chronica Minora* **2**: 191); Theodore Lector, *Hist. eccl.* **2**, 1 (Migne, *Patrologia Graeca*, LXXXVI, 1, col. 184 B); Cedrenus, I, 618.22–619.6 Bonn ed.); Leo Grammaticus, 117.16–21 Bonn ed.; Joel, 43.6–12 Bonn ed.; Nicephorus Callistus, *Eccl. hist.* **16**, 37 (Migne, *Patrologia Graeca*, CXLVII, 200 C); Georgius Monachus, **2**: 619.1–8 ed. De Boor; Theodosius of Melitene, p. 82, ed. Tafel.

[33] W. Telfer, The Didache and the Apostolic Synod of Antioch, *Journal of Theological Studies* **40**: 137, 1939.

[34] It is to be noted that some of the ancient sources state that Cyprus was to be subject, in some respects, to Constantinople. It has been supposed that "Constantinople" represents a slip of the pen for "Constantia." See Hill, *History of Cyprus* **1**: 278, n. 3.

[35] Canon 39 of the Council in Trullo (Mansi, IX, 961). The status of the church of Cyprus is said in this canon to be based on "canon" 8 of Ephesus.

[36] A Latin translation of the Arabic canon concerning Antioch and Cyprus is printed in Mansi, II, 964, c. 37 (*cf.* 994, c. 43). On the falsity of the Arabic canons of Nicaea, see Hackett, *op. cit.*, 14–16, and Hefele-Leclercq, *Histoire des conciles* **1**: 512–520.

# NOTES ON AESCHYLUS' *PROMETHEUS BOUND*

HERBERT S. LONG

Department of Classical Languages, Hamilton College

AMONG the Greek dramas that have survived to modern times, few have been the object of more interest, study and disagreement than the *Prometheus Bound*. Scorned by the orderly eighteenth century, admired by the Romantics of the nineteenth, the play is still being studied by professional scholars and read by a wider public; and no year passes without its share of new publications on *Prometheus*. In the following Notes I shall not concern myself with a number of problems that have been vigorously explored for the past hundred years. I shall not, for example, attempt to determine the date of the play, or try to illuminate the play from outside by looking for references to contemporary persons and events or by citing parallels of thought and language in other works of Greek literature (many such parallels are adduced by Thomson and Groeneboom, to name only two editors); nor shall I concern myself with the staging of the play. Rather, I propose to study the vocabulary closely, taking full account of the many and striking repetitions; and to examine the leading metaphors, their interrelationships and what they contribute to understanding the play as a whole, while recognizing that if we had the other two plays of the trilogy, our interpretation of particular points would undoubtedly be broadened or changed.

Although I neither began nor carried out this study with a view to refuting the suggestion that *Prometheus Bound* is not by Aeschylus, a theory whose most serious exponent was Wilhelm Schmid ("Untersuchungen zum Gefesselten Prometheus," *Tübinger Beiträge* **9**, Stuttgart, 1929), I feel that these Notes answer one of Schmid's objections to considering the play authentic: viz., the abundance of verbal echoes and outright repetitions. A careful reading of the play has convinced me that the repetitions, far from being aimless and awkward, are highly meaningful and must have been used intentionally to produce a closely interwoven and subtle structure. It is my feeling that the play cannot be the work of some poetaster, as Schmid implies, but that it is a bold and, on the whole, successful experiment with a particular verbal device.

There have been many editions of the play since 1800, most of them slight, for the Greek of the play is easy and it has been much read in the schools. I have learned most from two of the larger editions, those of Thomson and Groeneboom, which tend to supplement one another. Yet neither of these editors is concerned primarily with the problems that I shall discuss in these Notes. I have read only part of the school editions in English and very few of those in other languages; but I observe that one or another of these editions will occasionally anticipate one of my own observations, and I do not doubt that an examination of all the school editions would disclose other such anticipations.

Two methods are available for examining the vocabulary and metaphors of a literary work. One can write essays on particular words or metaphors, drawing the evidence together from various parts of the original work, or one can compose notes *seriatim*. I have chosen the latter method because it seems to me essential for the reader's mind to travel through a work in order, from beginning to end, since elements of order are among the most essential aesthetic devices. An essay, on the other hand, concerning Prometheus' chains and the various metaphors used in connection with them would be a re-ordering of the play, a kind of rewriting of Aeschylus that would obscure the fact that all references to chains do not occur together, but are scattered throughout the play, each in its own context. Notes have their unavoidable disadvantages: some repetition, and many cross-references.

For the text and line numbers I have followed chiefly Murray's Oxford Classical Text of 1955. After the Notes I have appended an index of important Greek words and a selected bibliography, many of the titles in which are referred to by short title in the Notes. The abbreviations of the names of periodicals are those used by J. Marouzeau, *L'année philologique*. The symbol )( denotes a contrast.

For a number of valuable corrections and suggestions I am indebted to Professor Friedrich Solmsen of Cornell University and to an anonymous referee of the American Philosophical Society.

## NOTES

### PROLOGUE: 1–127

**1** Χθονὸς: Thomson claims that this word "strikes the keynote of the drama." How, is not clear: for although the word occurs twelve times in the play, its uses are not at all striking.

τηλουρὸν: Prometheus' place of punishment is remote, at the ends of earth. Similarly, Io will wander far at the earth's end and finally find rest in Egypt (807 f.). The first of many parallels between Prometheus and Io: *cf.* 15, 69, 93, 95, 98–100, 108, 158, 179, 237, 264, 267, 323, 578, 595, 597, 672, 690, 746, 748, 755, 807, 846, 879, 991, 1045, 1050 f., 1054, 1056, 1057, 1062.

**2** Σκίθην: Scythia symbolic of the uncivilized (evidence in Thomson), hence a fit place of punishment for the god who traitorously gave civilization to men (442–506). In 707–712 Prometheus warns Io of approaching the Scythians, who do not practice agriculture (*cf.* the Cyclopes), but live a nomadic life in covered wagons.

ἄβροτον . . . ἐρημίαν: Prometheus condemned to isolation, though the savage Scythians are close by. The god who loved mankind too well (φιλανθρώπου τρόπου, 11 and 28) shall be cut off from mankind (ἀπανθρώπῳ 20, ἀγείτονος 270, ἀστρογείτονας 721). Prometheus has been relegated to the realm of meteorological phenomena, with which Zeus attacks him at the end of the play (989–994, 1043–1050, 1080–1090), the elements, which he invokes as soon as he is alone (88–92), and the gods, who visit him throughout the play. His ἐρημία is thronged, but not with mortals. The variant reading ἄβατον does not bring out the appropriateness of Prometheus' punishment so clearly.

**3 f.** Cratos reminds Hephaestus of his duty to Zeus, as Hermes reminds Prometheus at 947 f. Cratos and Hermes are both zealous flunkies. Cratos is the embodiment merely of Zeus' physical power, as his name implies, while Hermes voices Zeus' point of view. Cratos addresses Prometheus only to insult him (82–87), while Hermes uses both persuasion and threats. Prometheus does not speak to Cratos; by the time Hermes appears, Prometheus has grown self-confident and defies Zeus to do his worst.

**4** πατὴρ: A purely genealogical relationship )( the Jewish-Christian concept of the fatherhood of God. Zeus as father appears in different lights as the play progresses. In 4, 17, 40, and 53 he commands with unquestioned authority; but he is insecure in his relationships, for we learn at 768 that Thetis may bear him a son more powerful than himself, and at 910 that he is under the curse of his own father. At 947, 969, and 984 Zeus commands and is refused. In the Homeric poems Zeus is often called πατὴρ ἀνδρῶν τε θεῶν τε. At the start of his reign Zeus was concerned only to rule the gods; for the other part of his brood, men, he shirked his responsibility (228–233), which was then assumed by Prometheus. Prometheus was Zeus to mankind, knows it, and is proud of it (234 f., 442–446, 502–506). In fact, because he helped Zeus to his throne he sometimes thinks of himself as a Zeus to the gods too (439 f., *cf.* 228–231). Prometheus and Zeus are much alike, as will appear: a fact that makes their conflict all the more bitter.

τόνδε: 43, 52, 70. Cratos uses the third person of Prometheus till he insults him (82 ff., Thomson), while Prometheus utterly ignores Cratos and Hephaestus (*cf.* n. 215).

**5** ὑψηλοκρήμνοις: n. 18.

λεωργὸν: Whatever the etymology of this word, it is the first indication in the play that the gods regard Prometheus as a criminal. It may be that the Greeks of the fifth century associated the first part of this compound with λεώς: *cf.* Suid., *s.v.*; Schol. *ad loc.* If so, the word embodies the essence of Prometheus' crime in the eyes of the gods: he worked for the people.

ὀχμάσαι: also 618. Metaphor from harnessing a horse (Groeneboom; and Dumortier, *Les images*, 63). The first of many metaphors based on the control of domestic animals. Tyrants reduce their victims to the state of subjection in which men hold animals: a topos in Greek tragedy. Dumortier, *op. cit.*, Chap. IV, *Le harnois de Prométhée*, maintains that this is the dominant metaphor of the whole play; it is, in fact, frequently used, but other metaphors (e.g., inflexibility) are even commoner, and there is no reason why we should regard a play as having just one dominant metaphor. Del Grande, *Hybris*, 453, is surely nearer the truth when he lists six (perhaps seven) dominant themes.

**6** ἀδαμαντίνων . . . ἀρρήκτοις: Cratos calls the fetters unbreakable and not capable of being

overcome, and Prometheus' future seems hopeless as the harsh, unsympathetic Cratos describes it; but even at 19 Hephaestus, a fellow-god, tones ἀρρήκτοις down to δυσλύτοις. Presumably Hephaestus too thinks Prometheus' fate hopeless, but he does not wish to state the truth with unkind bluntness. By 771, 785 ὁ λύσων is in sight. ἀδαμάντινος is used again in 64 of the wedge driven through Prometheus' breast, and ἀδαμαντόδετος in 148 of the chains; but Prometheus will escape both them and the power of Zeus. Paradoxically, Prometheus will escape Zeus' domination through the aid of Heracles, the descendant of Io, who is called the δάμαρ (834) of Zeus; and Zeus' power is threatened by a child that may be borne to him by Thetis, another δάμαρ (767). Similarly, 49 Aegyptiads were subdued by their Danaids (861). The seemingly weak can overcome the apparently invincible. In truth, the adjectives ἀδαμάντινος and ἄρρηκτος suit Prometheus more than his chains: on Prometheus' character see J. Davison in *TAPA* **80**: 67–73, 1949.

**7** τὸ σὸν ... ἄνθος: Fire, named third (252) in Prometheus' list of his gifts to man, is brought forward here as an argumentum ad Hephaestum (so Schol.). Hephaestus takes no notice of it (Thomson on 29–30).

παντέχνου: Fire is important to men chiefly for the crafts that it makes possible (254). The word τέχνη, as Solmsen remarks (p. 141 f.), leads Aeschylus to elaborate Prometheus' services to mankind: *cf.* μηχανήματα (469), τέχναι (506). In 110 fire is called the διδάσκαλος τέχνης πάσης βροτοῖς (*cf.* 254). From 253 f. and 506 it appears that Prometheus is πάντεχνος more truly than fire, just as he is more invincible than his bonds.

πυρὸς σέλας: *cf.* φλογωπὸν πῦρ (253), Rose in *Eranos* **45**: 93, 1947.

**8** θνητοῖσι: The various words for *gods* and *mortals* are exceedingly common in this play, which concerns the relations between gods and men and the fate of a god who dared to cross the boundary of divine privilege.

| | |
|---|---|
| θεός—33 times | θνητός—16 times |
| θεόσ(σ)υτος—3 | βροτός—13 |
| δαίμων—5 | βροτοστυγής—1 |
| μάκαρ—2 | ἐφήμερος—3 |
| | ἐφημέριος—1 |
| | ἄνθρωπος—2 |
| | φιλάνθρωπος—2 |
| 43 | 38 |

κλέψας: Prometheus' crime is here identified as κλοπή (*cf.* 82 f., 109 f., 252, 612, 946, and del Grande, 99–104). Prometheus admits the charge at 110 and Hermes, who is in some respects a renewal of Cratos, repeats the charge in 946. The word γέρας (see Index) expresses a similar notion. *Cf.* Davison, *op. cit.*, 68 f.

ὤπασεν: *vox propria* of Prometheus, *cf.* 30 and 252.

τοιᾶσδέ τοι: Prometheus flings this type of accusation back at his enemies in 221, 237, 913, and 920 (Thomson). He is far from meek and submissive.

**9** ἁμαρτίας: To Cratos and Hephaestus (30) Prometheus is a sinner against the divine order. In 259–261 the Chorus point out to Prometheus that he has sinned, and he freely admits it (266): in order to help men. Surely Farnell is wrong in *JHS* **53**: 43–45, 1933, when he states that Prometheus is sinless, "a noble and lovable being." Prometheus, like Antigone, has offended against the existing νόμοι because of other moral imperatives not recognized by the powers. Like Antigone, he might describe himself as a "righteous sinner," but he is none the less a sinner (266). Nothing could be less lovable than Prometheus' querulous and acrimonius self-righteousness; yet he acted from a noble motive, pity for man's hard lot (239).

θεοῖς: the counterpart to θνητοῖσι (8).

δίκην: elsewhere only at 30. In 976 and 1093 Prometheus calls his punishment unjust, but that feeling comes to him only after witnessing the spectacle of Io's sufferings and hearing the threats of the contemptible lackey, Hermes. δίκη is not a leading idea of this play, as it is in the *Oresteia* (n. 30); it is Zeus' dignity and self-importance that have been offended, not Justice. E. Wolf, *Griechisches Rechtsdenken* **1**: 371–378, Frankfurt a.M., 1950, interprets the whole Prometheus trilogy as a conflict between the hybris of Prometheus and the δίκη of Zeus; but the true state of affairs is shown by the fact that Kaufmann-Bühler has almost nothing to say about *Prometheus*.

**10** διδαχθῇ: Throughout the play there is great emphasis on learning and teaching, primarily because Prometheus was a great teacher of mankind. Cratos, both here and at 62, turns Prometheus' ability as a teacher into an insult: the teacher will now be taught his inferiority to the power and wisdom of Zeus. The advice of the Chorus, "Physician, heal thyself," is similar (472–475). On the theme of πάθει μάθος see

Dörrie, especially p. 327 f. Verses 442 ff. show how Prometheus taught men to use their wits.

τυραννίδα: With διδαχθῇ this gives us the antinomy of power *vs.* intelligence: Havelock, Chap. 8. Zeus as tyrant is a theme developed with a wealth of metaphorical detail: *cf.* Nestle, 29–34, and Todd, "The Character of Zeus," *CQ* **19**: 127–130, 1925. Zeus' tyranny has been a happy hunting ground for those who look for contemporary allusions: e.g., Stoessl in *AJP* **73**: 127–130, 1953, gives a political interpretation of the whole play and finds in it references to the struggle between Themistocles and Cimon in 474/3; while Davison, *loc. cit.*, sees references to the events of 463–457 and identifies Cronus with Cimon, the Titans with Athenian conservatives such as Ephialtes, and Zeus with Pericles. Such identifications, with our incomplete knowledge of the mid-fifth century, can be no more than entertaining speculations, true though it is that Aeschylus and his contemporaries must have formed their concept of tyranny at least partly from the events of their own day. Zeus is a tyrant, not for the sake of some local allusions, but because tyranny is rule by force: Reinhardt, *Aischylos als Regisseur und Theologe*, 42–48. Knight's attempt to plumb the subconscious of Aeschylus and identify the struggle of Zeus and Prometheus with the struggle between group values and the individual's self-expression seems speculative in the extreme (*JHS* **58**: 53 f., 1938). Nor can we accept the suggestion of Davison, *op. cit.*, 73, that Zeus' "apparent cruelties" are instruments for the accomplishment of his "large and loving purposes." Zeus is not Jehovah, to chasten whom he loves. If Zeus' purposes are large and loving, no character in the play has found it out. Even his love is destructive.

**11** στέργειν: Ironical, particularly in conjunction with φιλανθρώπου. Prometheus has loved mankind too well (also 28 and 123); now he must learn to love Zeus, his worst enemy.

παύεσθαι: In fact, Prometheus is inflexible like his bonds and the rock to which he is chained. Later he ceases, not his philanthropy, but his lamentations (615).

**12** Κράτος Βία τε: Cratos represents Zeus' supremacy; Bia, a mute person, the brute force by which Zeus maintains his supremacy.

ἐντολή: refers back to ἐπιστολὰς (3). Zeus is a tyrant, and is usually obeyed: *cf.* 1032, 1080, n. 4. Cratos and Bia have finished their task, to bring Prometheus to the earth's end, and nothing now lies before them (ἐμποδὼν) to do. But ἐμποδὼν is used in a double sense: not only does the actual chaining of Prometheus to the cliff lie before Hephaestus, but it is a stumbling block to him, for he, unlike Cratos, feels sympathy for a fellow-god. Vandvik, whose interpretation of the play is full of bizarre perversities, believes (39) that Zeus pitied Prometheus as much as Hephaestus did.

**14** ἄτολμος: Hephaestus lacks the θράσος, τραχύτης that characterize Cratos and, by implication, Zeus. *Cf.* n. 42.

συγγενῆ: The Scholia here and on 39 suggest that συγγενής is used because Hephaestus regards Prometheus as a fellow-god of handicrafts. Groeneboom finds the suggestion over-ingenious.

**15** δῆσαι: *cf.* 119 and the title of the play.

βίᾳ: A pun on the name of Bia, proving—what is obvious—that the name is significant. Nomen omen: *cf.* 717. The play contains at least eight puns (possibly ten), all used in connection with the fates of Prometheus and Io: *cf.* 55, 74, 86, 101, (576, 694?) 733, 840, 849.

φάραγγι: Also used of Prometheus' place of punishment at 142, 618, 1017.

δυσχειμέρῳ: used of Io at 746. Both Prometheus and Io are storm-tossed by Zeus. *Cf.* n. 562.

**16** ἀνάγκη: *cf.* 72. The constraint of Zeus lies heavy upon his subjects. Of Prometheus: 105, 1052. The chains (108) are the embodiment of the ἀνάγκη that Zeus wields; but, paradoxically, Zeus himself is subject to ἀνάγκη (515–518): he is as truly bound as Prometheus.

τόλμαν: *cf.* ἄτολμος (14), Thomson.

**17** πατρὸς: n. 4. πατρὸς λόγοι = ἐπιστολαί (3) and ἐντολή (12). A tyrant's every word is a command.

βαρύ: The hand of Zeus is heavy upon the gods: *cf.* 77, and )( Prometheus' dealings with Io and the Chorus (701).

**18** ὀρθοβούλου: Though Prometheus is the son of Themis, whose deliberations are aright, his own thoughts have been haughty and hubristic (αἱπυμῆτα) and lacking in εὐβουλία, as Hermes later tells him (1008–1035). The place of Prometheus' punishment is doubly appropriate: it is remote from men (n. 2) and it is high, like his own thoughts. With αἱπυμῆτα *cf.* αἱπύνωτος of Dodona (830); and with ὑψηλοκρήμνοις (5) *cf.* ὑψήγορος of

Prometheus (318). Moreover, Prometheus, the πολυπράγμων (505 f.), is immobilized and reduced to the ὀλιγοδρανία (548) of men. The punishment, by contrast and various correspondences, perfectly fits the crime: *cf.* also 2, 6, 10, 19, 32, 87, 108, 142, 163, 195, 269, 314, 327, 370.

**19** ἄκοντα . . . ἄκων: *cf.* 671. Hephaestus is as reluctant to bind Prometheus as Inachus was to expel his daughter, but both felt powerless to resist Zeus' ἀνάγκη. Anadiplosis is very common in this play: 29, 37, 92, 119 f., 192, 106 f. sim. 197 f., 218, 266, 310, and 671. Editors comment on the form but not on the significance of these tropes, which are mostly associated with the struggle between Zeus and his subjects or opponents.

δυσλύτοις: Not ἀλύτοις (154), *cf.* n. 6. Hephaestus euphemistically terms the chains "hard to loose," just as at 60 he says that Prometheus' arm is fastened δυσεκλύτως and at 34 he calls the mind of Zeus δυσπαραίτητοι. In the sequel Zeus *was* persuaded and Prometheus *was* loosed, just as he himself had saved men (935). *Cf.* n. 166.

χαλκεύμασι: The working of metals was one of Prometheus' gifts to men (502), *cf.* n. 18.

**20** προσπασσαλεύσω: 56, 65, 113. Groeneboom queries whether the verb alludes to crucifixion, as in other versions of the story.

ἀπανθρώπῳ: n. 2. *Cf.* 21 f.

πάγῳ: of Prometheus' place of punishment also 117, 130, 270.

**22** ἡλίου: sun as tormentor )( sun as witness in 91 f. Even in his first words Prometheus is less concerned with his sufferings than with the excessive nature of his punishment.

**23** ἀμείψεις: looks to a physical change in Prometheus, while παύεσθαι (11) looks to a mental. ἀσμένῳ: n. 395, and *cf.* Deuteronomy 28: 67.

**27** ὁ λωφήσων: Euphemism, as at 19; but ὁ λύσων appears at 771, 785, and Prometheus alludes to the end of Zeus' wrath as early as 376. According to Dumortier, *Images*, 64, λωφᾶν refers to the head-shaking of an animal just released from the yoke; if so, *cf.* n. 81. Barbara H. Fowler gives the verb a medical sense: *AJP* **78**: 176, 1957.

**28** ἐπηύρου: ironical, as this verb often is.

φιλανθρώπου τρόπου: as in 11. Hephaestus is equal with Cratos in condemning Prometheus' philanthropy, but he regards it in a different way. To Hephaestus Prometheus' philanthropy is the cause of the sufferings that grieve Hephaestus; to Cratos Prometheus' philanthropy is an evil trait that must be corrected.

**29** θεὸς θεῶν: 37, 92, 119 f. In all four passages the anadiplosis (n. 19) marks Prometheus as the maverick at odds with the other gods. Prometheus too is aware and proud of his uniqueness (234, 502 f.).

ὑποπτήσσων: Cowering like animals and birds, and like Hephaestus before the wrath of Zeus, )( Prometheus at 174 and 960.

**30** The sin of Prometheus reinterpreted in a wider sense than by Cratos. Fire (7 f.) was but one of the θεῶν τιμαί stolen by Prometheus. Thomson compares 542–544.

τιμὰς: 946. γέρας (38, etc.) is similar.

ὤπασας: 8.

πέρα δίκης: *cf.* n. 9 and v. 507. By 976 Prometheus is convinced that his punishment is unjust: *cf.* Hirzel, 221. Zeus' attendants are Cratos and Bia, not Dike; and Prometheus at last charges Zeus with injustice (1093).

**31** ἀτερπῆ: There is little joy in the play and most of it is bitter, ironical or cruel: *cf.* nn. 156–158, 160, 314, 536, 629, 631, 641 f., 698, 758, 818, 1024.

φρουρήσεις: *cf.* φρουρὰν ἄζηλον (143).

**32** ὀρθοστάδην: A consequence of Prometheus' not being like ὀρθόβουλος Themis (n. 18).

οὐ κάμπτων γόνυ: rigid, inflexible in body as well as in spirit.

κάμπτειν suggests the breaking of animals (323, 597, 692, 1009–1011): Stanford, 98. At 396 Ocean's steed wants to rest (*cf.* ἀσμένῳ, 23) *and can.*

**33** ἀνωφελεῖς: Prometheus helped both Zeus (222) and man (251, 501, 507, 613), but cannot help himself: *cf.* 43 f. The theme of wasted labor is further developed in the scene with Ocean: 341–343, etc.

**34** δυσπαραίτητοι: n. 19. Zeus' mind is like that of the Erinyes (*Eum.* 384); and, like them, in the end he relented.

**35** Groeneboom (15, n. 35) terms this verse the keynote of the play. Baglìo (9–11) sees a reference to Xerxes. Vandvik (40 f.) believes that Zeus is really just and that his supposed harshness is a delusion of Prometheus: and he

would translate ἅπας τραχὺς "*appears to be* severe." This must be a mass-delusion, for no character in the play considers Zeus kind, loving, and just.

τραχὺς: of Zeus also in 324, Cratos (80), and Prometheus (311). *Cf.* n. 42.

νέον: Forms of νέος occur thirteen times in the play, eleven times with reference to Zeus (95, 149, 310 bis, 389, 439, 942, 955 bis, 960); *cf.* also νεοχμός (150), νεοζυγὴς (1009). This constant harping upon Zeus' newness may indicate that he can improve in time: Todd, p. 62. The commentators have all remarked upon Zeus' newness, from the Scholia on: *cf.* especially Solmsen, 150–152. The two remaining uses of νέος are instructive. At 170 Prometheus hints at a νέον βούλευμα that will someday cause Zeus' overthrow (viz., his determination to have a child by Thetis): Zeus will fall by νεωτερισμός, just as he came to power. And in 233 Zeus plans to create a new human race, thus making a complete sweep in his accession to power: *cf.* νεοχμοῖς νόμοις (150).

**36** μέλλεις: *cf.* ἑλινύω (53, 529) and τρόχις (941). The servants of tyrants must step lively. Hephaestus delays out of sympathy for Prometheus, just as Prometheus at 627 is reluctant to reveal Io's future.

κατοικτίζῃ: The theme of sympathy is very fully developed in the play, especially with reference to Prometheus, Io and primitive man. See Index, *s.v.* ἀποδύρομαι, ἀποκλαίω, ἀρήγω, ἄρηξις, βοάω, δάκρυ, δάκρυον, δακρυσίστακτος, δυσθέατος, θρηνέω, θρῆνος, κέαρ, λεωργός, μετέχω, ξυνασχαλάω, οἰκτίζω, ὀλοός, πάσχω, πονέω, στένω, compounds of συν-, ταλαίπωρος, τάλας, and χάρις.

μάτην: Wasted effort (44, 342, 447, 504, 1001, 1007), typified by Typho (363 f.). Hephaestus' sympathy for Prometheus is as useless as Prometheus' plaints will be (33).

**37** θεοῖς . . . θεόν: n. 29.

στυγεῖς: Hephaestus should hate Prometheus, but he really hates his own skill (45 f.), which enables him to bind Prometheus. Prometheus is free to say that he hates his enemies (978), especially Zeus (1004), and thus comes to the frame of mind that Cratos expresses here.

**38** τὸ σὸν . . . γέρας: renews τὸ σὸν ἄνθος (7). γέρας in same sense: 82, 107, 229.

προὔδωκεν: Prometheus betrayed the gods, the notion expressed by anadiplosis of θεός. In the end the Chorus refuse (1068) to betray Prometheus.

**39–81** Unusual stichomythia: Hephaestus speaks one verse to Cratos' two. Hephaestus is distressed, uneasy in his conscience, and busy, while Cratos is self-assured (Groeneboom).

**39** τὸ συγγενές: renews 14. In 290 Ocean raises the same consideration. Though both Hephaestus and Ocean are aware of the claims of kinship, both fear the power of Zeus. Hephaestus reluctantly does his duty, prodded by Cratos; Ocean rather easily gives up trying to help Prometheus, though he is warmer than Hephaestus in his protestations of friendship.

ὁμιλία: As fire-gods, united in Attic cult? (Sikes and Willson, Groeneboom)

**40** ἀνηκουστεῖν: Exactly what Prometheus and the Chorus do at the end.

πατρὸς λόγων: *cf.* 17. Cratos reminds Hephaestus of his previous statement.

**41** δειμαίνεις: The emotion tyrants inspire is fear, not love (11). Even Prometheus, who is usually bold (29, 542, 932, 960, 1003), fears briefly at 124–127 and 1090, near the beginning and end of his being on stage, as Io fears at 580 and 881. The Oceanids are afraid for both Prometheus and Io: 144, 181 f., 696 (*cf.* 901 f.).

δειμαίνεις echoes δεινόν (39): Weil.

**42** νηλὴς: Cratos is an extension of the personality of Zeus (240): so Scholia. )(Prometheus' pity for men (239).

θράσους: Cratos, Prometheus (178), Heracles (871) and Zeus (916) share this quality with the Danaids (861), and Prometheus tells Io (730) that she would do well to cultivate it. The victims of tyranny are forced to become like their oppressors: so Prometheus is as harsh and stubborn as Zeus (*cf.* Finley, 222 f., 230), and would be equally intolerable if he kept the same character in favorable circumstances (979).

**43** ἄκος . . . οὐδὲν: First appearance of the disease metaphor: Prometheus cannot be helped, although he taught remedies to men (482). *Cf.* 472–475. For a thorough discussion of the disease imagery and its implications, see Barbara H. Fowler, "The Imagery of the *Prometheus Bound*," *AJP* **78**: 173–184, 1957.

**44** τὰ μηδὲν ὠφελοῦντα: *cf.* 33. Cratos compares Hephaestus to Prometheus with his useless lamentations. Prometheus talks to Ocean in the

same vein, since he knows that his position is hopeless until the fullness of time (342 f.). Cratos and Hephaestus think it completely hopeless.

μὴ πόνει μάτην: *cf.* 36, 342 f.

**45 f.** *Cf.* n. 37.

**46** πόνων: Many times of the sufferings of Prometheus and Io (n. 267); once (425) of Prometheus' brother, Atlas; in 75 of Hephaestus (see n. there); paradoxically of Zeus at 931, an instance of the theme ἴσα πρὸς ἴσα, which is common in the play, since Prometheus longs for the day when the tables will be turned.

ἁπλῷ λόγῳ: *cf.* Thomson. παρρησία is a privilege of tyrants, but Prometheus cultivates it freely in the play: 610, 975, λαβροστομέω (327), ἐλευθεροστομέω (180), n. 42. I believe Hiltbrunner mistaken (76) when he finds the repetition of ἁπλῷ λόγῳ without significance. Groeneboom takes the phrase to mean "speaking generally," but that meaning seems unlikely in 975 and will not do in 610.

**47** τῶν νῦν παρόντων: *cf.* 26 and n. 271. Cratos and Hephaestus tend to live in the present, while Prometheus ranges through all time and space.

τέχνη: 110, 254, 477, 497, 506.

**50** ἐλείθερος: The tyrant alone is free, not responsible to anyone (324); but Prometheus, though confined in body, is free with his tongue (n. 46).

**51** Hephaestus begins to weaken, and Cratos renews his urging.

**52 f.** ἐπείξῃ . . . ἑλινύοντα: n. 36.

**53** προσδερχθῇ: The formidable eye of the gods, feared by the Chorus in 903. *Cf.* baleful eyes of Typho (356), Argus (569), Zeus (654), Graeae (795). The baleful stare of enemies is what Prometheus dislikes most in his extremely public place of confinement: hence, his extraordinary sensitivity to being stared at (152 ff., etc.). Prometheus is in the pillory.

πατήρ: n. 4.

**54** ψάλια: Part of a harness: Scholia. *Cf.* n. 5. Thomson, *ad loc.*, collects the harness metaphors.

δέρκεσθαι: picks up προσδερχθῇ. If Zeus cares to look he can see the fetters ready to put on Prometheus: *cf.* 562.

**55** ἐγκρατεῖ: Cratos puns on his own name, *cf.* n. 15. Cratos is the manifestation of Zeus' power: Maddalena, p. 136.

σθένει: The strong men are Cratos, Typho (362) and Atlas (428). The power of the latter two has been overcome, and Cratos' power may come to nothing, for brute force can be overcome by guile (212 f.), a fact of which Cratos is fully aware (87).

**56** βαιστῆρι: The βαιστήρ may be used on Zeus one day (189): ἴσα πρὸς ἴσα, n. 46.

θεῖνε: 76. Cratos is unfeeling and hard; but so is Prometheus, for it is Hephaestus who groans (66) when the wedge is driven into Prometheus' breast.

**57** Hephaestus is finally getting into the spirit of serving a tyrant, *cf.* 52 f. ματᾷ recalls 44. *Cf.* 12 f.

**58** χάλα: Of Prometheus' bonds also 176, 256, 991. A grim joke, destined to be literally fulfilled.

**59** δεινὸς . . . εὑρεῖν: well describes Prometheus, the author of a whole series of devices (469), who counselled αἰμύλαι μηχαναί (206) to check the rule of Zeus. δεινότης is another point of similarity (n. 42) between Prometheus and Zeus, for εὑρίσκειν is used in the play only of Zeus (96, 578, 922) and Prometheus (59, 249, 267, 468, 475). The εὑρήματα of Prometheus are all beneficient; those of Zeus, destructive. Zeus exemplifies the misuse of power.

ἀμηχάνων: *cf.* 469.

πόρον: 111, 477.

**60** δυσεκλύτως: n. 19.

**61** πόρπασον: *cf.* πόρπαξ, part of a harness (Thomson on 54). LSJ[9] probably wrong to connect the verb with πόρπη, "fibula."

**62** Jibe of the teacher taught, n. 10. In 926 (*cf.* 944) the tables are turned. Prometheus is proverbially wise: σόφισμα (459, 470, 1011), σοφιστής (62, 944), σοφός (936, 1038 f.). Zeus, who should be wise, is in fact only powerful in this play.

**64** ἀδαμαντίνου: n. 6.

αἰθάδη: *vox propria* of tyrants, who please only themselves, *cf.* 50. The wedge is the instrument of Zeus (907). αἰθαδία is attributed to Cratos (79), but chiefly to Prometheus (436, 964, 1012, 1034, 1037). αἰθαδία is another quality that

Prometheus shares with Zeus, along with *θράσος* and inventiveness: nn. 42 and 59. H. G. Robertson in *CPh* **34**: 218, 1939, is, I believe, wrong in positing a conflict between Prometheus' *αἰθαδία* and Zeus' *τραχύτης*; both Prometheus and Zeus possess both qualities. Hermes, on the other hand, lives to please Zeus. On *αἰθαδία* *cf.* Bacon in *CR* **42**: 115 f., 1928, and Schmid, *Griech. Literaturgesch.* **3**(1): 288, n. 10.

*γνάθον*: In 368 of devouring, volcanic fire. *Cf.* Prometheus' eagle and Io's gadfly.

**65** *πασσάλευ'*: 20, 56.

*ἐρρωμένως*: 76. *Cf. θεῖνε* in 56 and 76. Cratos is monotonously tough.

**66** *στένω*: Prometheus, the object of many groans (68, 397, 409, 432, 435), does rather little groaning himself (99) and presently renounces lamentation completely (615). It is the weak Hephaestus who groans.

*πόνων*: n. 46.

**67** *αὖ*: *cf.* 36.

*κατοκνεῖς*: In 628 Prometheus is reluctant to tell Io her future woes.

*Διὸς . . . ἐχθρῶν*: *cf.* 37. The hatred is mutual: 975.

**68** Prometheus warns Ocean similarly (344–346, 373 f., 390); Hermes, the Chorus (1058–1062). All know Zeus' malice.

**69** Hephaestus and Cratos pause to survey their work. Prometheus is now a public spectacle: n. 53. All four words in the line denote looking, and form a quasi-chiasmus. Looking and staring are very common in the play: see Index, *s.v.* *δέρκομαι, ἐπόπτης, ἐσοράω, ἐφοράω, θέα, θέαμα, θεωρέω, θεωρία, θεωρός, καλύπτω, κρύπτω, λαμπρῶς, λεύσσω, ὄμμα, ὁράω, ὅσσε, πανόπτης, προσβλέπω, προσδέρκομαι, προσοράω, φάος.*

*δυσθέατον*: Of Io in 690. On the parallels between Prometheus and Io, *cf.* n. 1.

**70** *ὁρῶ*: mockingly echoes *ὁρᾷς*, a common device in the play: *cf.* Thomson on 36–81.

*ἐπαξίων*: Prometheus knew that he would be punished, and rightly according to Zeus' point of view, but he regards the method of his punishment as excessive (266–270). Vandvik, 41, accepts *ἐπαξίων* as literally true.

**71** *μασχαλιστῆρας*: Further use of animal imagery. The victims of tyrants are treated no better than animals, and Io becomes one.

**72** *ἀνάγκη*: n. 16.

*μηδὲν ἐγκέλευ' ἄγαν*: The famous Delphic adage, also in 327. Other references to Delphi are latent in Prometheus' oracular responses to Io and the Chorus, and in his method of answering their questions: n. 778. Hephaestus finds Cratos too bossy. Excess is found in Prometheus at 123, 180 ff., 318, 327, 544, 123, 383, 328, 1011. On excess in Aeschylus: Solmsen, 146 and n. 102.

**73** *κελεύσω*: picks up *ἐγκέλευ'*. Hermes, another self-important flunkey, treats the Chorus similarly (1066).

*ἐπιθωύξω*: "halloo on the hounds" (Thomson: omitted by Mielke, 82–84). Cratos treats Hephaestus as an inferior, but Hephaestus takes no notice of it. Hermes, who talks in the same way to Prometheus (1041), gets a stinging retort. Hermes is like Cratos in his complete and self-important dedication to Zeus, but he is physically weaker and lacks *αἰθαδία*: thus we have *ἔργα* in the Prologue (57, 75, 77), but *λόγοι* (1080) in the Exodos, until Zeus intervenes personally. Cratos attacks Prometheus' person; Hermes tries to shake Prometheus by words. Prometheus says nothing to Cratos, but pours out his wrath on Hermes, who commands less respect because of his weakness.

**74** *κίρκωσον*: *cf. κρίκος*, part of a harness (Schol., Thomson).

*βίᾳ*: as in 15. Cratos enjoys using *βία* and talking about it, Hephaestus does neither, and Hermes enjoys threats but cannot carry them out. *βία* characterizes the struggle between Zeus and the Titans (208, 353, 357), as well as Zeus' treatment of Io (592, 737) and her father (672); Prometheus' reaction to Zeus is violent (1010).

**75** *οὐ μακρῷ πόνῳ*: )(the prolonged *πόνοι* of Prometheus (n. 46) and Io. Hephaestus seems uneasy that a few minutes of his own work will confine Prometheus for ages or forever.

**76** *ἐρρωμένως . . . θεῖνε*: 65 and 56.

*διατόρους*: At 181 the Chorus' heart is pierced with fear for Prometheus.

*πέδας*: About the ankles of Prometheus (*cf. χώρει κάτω*, 74); hence, probably another animal metaphor, since Homer uses *πέδαι* of spancels.

**77** *ἐπιτιμητής*: The tyrant is also a supervisor of work done: *cf.* Zeus in the role of an *ἐπίσκοπος* in 53 (Groeneboom).

*βαρύς*: n. 17.

**78** Mental state (as displayed in words) and appearance correspond: so of Io in 673. The victim and the minion of tyranny are equally distorted. No doubt a reference to Cratos' mask (Schol.).

**79** μαλθακίζου: Hephaestus is soft; Prometheus, Cratos and Zeus (952) are alike in being hard. It is characteristic of Groeneboom that he notes the repetition of μαλθακίζομαι in 79 and 952, but does not consider its significance. Inflexibility of Prometheus: n. 6, 379, 1008. Prometheus predicts the softening of Zeus in 188.

αἰθαδίαν: n. 64. Cratos is like the wedge, and Prometheus like the rock.

**80** ὀργῆς: Used of Cratos, Zeus (190), Prometheus (315, 378) and Argus (678).

τραχυτῆτα: Cratos is like Zeus (35, 186, 324) and Prometheus (311). Tyrants, their minions and their victims all tend to become alike: *cf.* n. 64. τραχυτής also occurs in nature: in 726 directed against Io, in 1048 against Prometheus. Correspondence of man and the physical world, as in 64 and 79.

**81** Hephaestus gives the reason for his presence in one verse, Cratos in eleven (1–11): Groeneboom. Hephaestus' reason ends the stichomythia: *cf.* n. 39–81.

ἀμφίβληστρ': Animal imagery: *cf.* ὀχμάσαι (5), ὑποπτήσσων (29), ψάλια (54), πόρπασον (61), μασχαλιστῆρας (71), ἐπιθωύξω (73), κίρκωσον (74). Animal imagery is concentrated in the Prologue because the binding of Prometheus represents his reduction to the status of an animal.

**82** ὕβριζε: Prometheus' sin regarded as hybris: *cf.* nn. 9 and 30. In 970, if the MS ascription of the verse to Prometheus is kept, Prometheus turns this insult against Hermes. Hybris has its physical analogue in the River Hybristes (717): *cf.* n. 80.

γέρα: n. 38. Now that Hephaestus has bound Prometheus, Cratos no longer emphasizes the theft of fire (7, 38), but describes the sin of Prometheus in broader terms, as Hephaestus himself did at 29 f. θεῶν γέρα, *cf.* θεῶν τιμὰς (29 f.).

**82 f.** θεῶν . . . ἐφημέροισι: The central opposition of the play: *cf.* 732 and 945.

**83** συλῶν: At 761 Prometheus predicts the theft of Zeus's sceptre. Here Cratos returns to the thought and tone of the opening.

**84** Men helpless to help their helper: *cf.* 545–550. Prometheus' labor for men was in vain: *cf.* 36, 43 f.

ἀπαντλῆσαι: Prometheus is prepared (375) to drain his own cup of woe.

πόνων: *cf.* 66 and )(75.

**85** ψευδωνύως: Nomen omen: n. 717, and Warburg, 76–86, esp. 77 f. All the puns in the play (n. 15) are bound up with the fates of Prometheus and Io. There is a sort of correspondence among name, character, role in life, appearance, and habitat, well illustrated by Cratos: harsh and powerful, serves a harsh tyrant, μορφή in 78, seen on the rugged Scythian crags. The third jibe at Prometheus' wisdom: *cf.* 10, 61 f.

**86** Prometheus proudly rejects this jibe in 101–103, and proves his foreknowledge by gradually revealing the future throughout the play. To Nestle (19 ff.) Prometheus is the embodiment of σοφία, especially political σοφία (199–221).

**87** ἐκκυλισθήσῃ: Since ἀμφίβληστρα (81) is near, Dawson (238) is probably right in taking the verb in the sense *escape from a net*, though Homer uses it (*Iliad* 17.688) of escape from the waves of calamity (*cf.* πέλαγος, 746).

τέχνης: bonds (Schol.). It is ironical that Prometheus, who taught men various τέχναι (110, 254, 477, 497) including the working of metal, should be confined by just this τέχνη. The dialogue ends with one of the key notions of the play: n. 7.

**88–127** Soliloquy of Prometheus, who says to nature what he would not say to his fellow-gods, thus emphasizing his isolation and solitude: Groeneboom. )(Hephaestus' expectation at 33 f. The powers of nature referred to here are developed from *Iliad* 3.276–278 (Thomson); they are not the four elements, which were not yet known as such, )(S. M. Adams in *CPh* **28**: 97 ff., 1933.

**88** αἰθὴρ: Prometheus' first and last words (1092 f.) are invocations to aether to witness his suffering, but his attitude to the suffering changes: *cf.* n. 92. Aether is the scene of Prometheus' punishment: 125, 158, 280, 394, 1044, 1088.

ταχύπτεροι: To carry his plaints far and wide: Groeneboom. The breezes foreshadow the coming of the Chorus (135), Ocean's steed (286) and the eagle.

πνοαί: breezes )(the blast of Io's madness at 884 and the hurricane of 1046 f., 1085 f. In 88–92 nature is smiling and friendly, for Prometheus' sufferings have scarcely begun.

**89** ποταμῶν . . . πηγαί: recur in 434, mourning for one of Prometheus' brothers. Water as man's helper: *cf.* relation of the Chorus to Prometheus.

**89 f.** ποντίων . . . κυμάτων ἀνήριθμον γέλασμα: *cf.* 746 and various cruel πόντοι in 726, 792, 1048, 1088. At 431 the sea sympathizes. Water that cannot be trusted: *cf.* relation of Ocean to Prometheus.

**90** παμμῆτορ . . . γῆ: Prometheus was one of her children (209 f.).

**91** πανόπτην: Sun invoked as a witness, *cf.* 92 f. Prometheus' public disgrace began in 69. He is willing and eager to be stared at by friends.

ἡλίου: Prometheus welcomes the sun as a witness, whereas sympathetic Hephaestus thought of the sun (22) only as augmenting Prometheus' pains. Prometheus' concern with his situation is usually more mental than physical.

**92** ἴδεσθε: *cf.* 91 and n. 69.

οἷα: )(ἔκδικα, 1093. By the end of the play, and even as early as 976, Prometheus has come to regard his punishment as unjust; in 92 f. he regards it as cruel and excessive.

θεῶν . . . θεός: n. 29.

**93** δέρχθηθ': *cf.* 91 f.

οἵαις αἰκείαισιν: make οἷα of 92 more explicit. αἰκεία is a technical term in Attic law for assault and battery: *cf.* 97, 472, 525, 1042; 177; 168, 195, 227, 256; 989. H. G. Robertson in *CPh* **34**: 215, 1939. Used once (599) by Io of herself. Prometheus regards himself as the victim of cruel and unusual punishment.

**94** διακναιόμενος and μυρι- are used by the Chorus in 541, as if they did the actual witnessing that Prometheus asks of nature.

μυριετῆ: μυρι- always (512, 541) of Prometheus' boundless suffering. All three uses come before 774, where a term is set of 13 generations. μυρι- is the converse of τέρμα (n. 100).

**94 f.** μυριετῆ χρόνον: In the *Pyrphoros* Prometheus' period of confinement was said to have been 30,000 years (Schol.); but 30,000 was practically equivalent to infinity (Pohlenz, **2**: 22). *Cf.* n. 774.

**95** ἀθλεύσω: ἄθλον of Prometheus 257, 262, 752, 934; of Io 634, 702; 752 brings both together—one of the many parallels between the two (n. 1). Io's δρόμοι (591, 838, cf. 883) elaborate the athletic metaphor.

νέος: n. 35.

**96** ταγός: A reference to Oriental absolutism (*cf. Persae* 324, etc.) or to Thessaly (Nestle, 29, n. 1).

μακάρων: )(ἀθλεύσω *sup.* The gods are blessed; Prometheus suffers. 976 expresses Prometheus' developed attitude to this situation. 168 f. contain a similar collocation: blessed Zeus, paradoxically, will one day need the poor sufferer.

ἐξηῦρ': n. 59.

**97** ἀεικῆ: n. 93.

**98–100** Fit words for Io: *cf.* 565, 586, 604 ff. A passing mood of discouragement, for Prometheus knows the future as Io does not.

**99** στενάχω: n. 66.

**100** τέρματα: *cf.* 184, 257 ff., 262, 755; 622, 706, 823, 828, 1026. Both Prometheus and Io will reach an end of their sufferings despite Zeus' present intentions.

ἐπιτεῖλαι: *cf.* 25, which Prometheus heard. The μόχθοι that he has in mind are those occasioned by the alternation of day and night.

**101** προυξεπίσταμαι: *cf.* 209–211, 873 f. Prometheus' retort to 85 ff. Prometheus not only has foreknowledge, but can impart it to Io (699). He knows all his future sufferings, but does not yet say anything about what is in the future for Zeus. The whole first part of this speech (88–113) turns on suffering: who will witness it, its violence and duration, who caused it and why.

**102** σκεθρῶς: 488 and n. 328.

**103 f.** πεπρωμένην . . . αἶσαν: Everyone must bear his fate, even Zeus (518 f.). Prometheus is fated to be loosed (512) and Io, to find rest in Egypt (815). Tyrant and victims are alike controlled by πεπρωμένη, *cf.* ἀνάγκη (n. 16).

**105** ἀνάγκης: n. 16.

σθένος: n. 55. The true σθένος belongs to ἀνάγκη, not to strong men, at whom ἀδήριτον looks. Atlas, Typho, and Prometheus were all overthrown by Zeus, just as Zeus overthrew Cronus; and Zeus himself is exposed to the same danger: 515–519, 920 f.

**106 f.** Same form of expression in 197 f., 238.

σιγᾶν: Prometheus is silent during 1–87 and 397–435, as well as for a time after 435 (*cf.* 436–438). Aeschylean silences: Groeneboom on 88–90.

τύχας: Many times of Prometheus; once (633) of Io; once of the Chorus (1073) when they resolve to share Prometheus' fate; once (769) even of Zeus.

**107 f.** θνητοῖς . . . γέρα πορών: *cf.* 82 f. Prometheus is well aware, as Cratos and Hephaestus were, that the theft of fire was but one part, though a conspicuous one, of his sin.

**108** πορών: Not κλέπτων or συλῶν: *cf.* 612. Prometheus regards the taking of fire as a gift and a benefaction to men, while the gods regard it as a theft. Prometheus gives also to Io (616) and to the Chorus (631). Prometheus' thoughts are of men; the gods' thoughts, of themselves and their prerogatives.

ἀνάγκαις ταῖσδ': chains, n. 16. Taken in conjunction with 105, this phrase indicates that Prometheus thinks his lot hopeless. In this soliloquy his feelings of helplessness, isolation and timidity (124–127) are at their maximum; as the play progresses he grows more self-assured. The implications of ἀνάγκη, like those of the compounds of δυσ- in the dialogue (n. 19) are ambiguous: Zeus, free though he seems (50), is bound by ἀνάγκη, and Prometheus will one day be free.

ἐνέζευγμαι: The image of the yoke (usual for ἀνάγκη: Thomson on 106–111) resumes the animal imagery of the dialogue (n. 81). *Cf.* Mielke, 21. Again of Prometheus at 1009. At 578 Zeus yokes Io. The yoking of Prometheus is part of the ironical appropriateness of his punishment (n. 18), for he taught men the domestication of animals (462 f.).

**109** θηρῶμαι: Prometheus' quarry was fire. The metaphor recurs at 1072, where the Chorus are warned that they may become the quarry of doom. In 858 the Danaids are the quarry of their cousins. By implication (θηρῶμαι *could* be passive), Prometheus and especially Io are the quarry of Zeus.

**109 f.** πυρὸς πηγήν: *Cf.* 89.

**110** κλοπαίαν:) (108. Prometheus now recognizes the gods' viewpoint (*cf.* n. 8).

διδάσκαλος τέχνης: interpret παντέχνου (n. 7). Prometheus as teacher answers the sneers of 9, 62, and 86 f. τέχνη and πόρος (111) reappear together in 477, for Prometheus' account of his benefactions to men only serves to show how he himself was διδάσκαλος τέχνης πάσης βροτοῖς.

**111** βροτοῖς: like θνητοῖς (107) is in opposition to θεοί (n. 8).

**112** ποινὰς . . . τίνω: As early as 176 Prometheus feels sufficiently self-assured to turn this phrase against Zeus. Verse 620, spoken by Io, echoes 112, while 985 is an ironic variation.

ἀμπλακημάτων: Also of Prometheus in 386 and 620. At the start of the play Prometheus is free to admit some guilt: *cf.* n. 9 and 266.

**113** ὑπαίθριος: carries us back to 88. 88–113 move circularly as do 7–83.

πεπασσαλευμένος: 56, 65.

**115** ἀχώ: In the play ἠχώ expresses four fearsome sounds: the sound of the approaching Chorus, which frightens Prometheus; the sound of Prometheus' chaining (133), which reached the Sea Nymphs' cave and moved them to lay aside maidenly modesty to come and investigate; the sound of the gadfly (575) that tortures and terrifies Io; and the sound of thunder (1082), heralding Zeus' final onslaught upon Prometheus and the Chorus, who have now resolved to share his fate.

ὀδμὰ: A scent of perfume (Schol.), so faint as to be unidentifiable. A helpless person clutches at every possible source of knowledge. *Cf.* Hom. *h. Dem.* 277, Eur. *Hipp.* 1391.

προσέπτα: *cf.* n. 88 (ταχύπτεροι). The audience (and Prometheus?) think of the eagle; similarly, the gadfly flew to Io. *Cf.* 555, 644.

ἀφεγγής: The sound and the odor tell him nothing.

**116** Logical analysis, *cf.* 765. For similar sets see van Otterloo, 72 f. and Kemmer, *Die polare Ausdrucksweise.* This type of classification is no mere trick of style or ornament, for the whole play concerns the opposing realms of gods and men (n. 8) and Prometheus, who has a foot in both camps. On Prometheus as a symbol of man see D. Grene in *CPh* **35**: 32–34, 1940, and Reinhardt, 48 f. Thomson remarks that Heracles too is both god and man.

θεόσυτος: Of god-sent evils—the gadfly (596), and a storm of woe that falls upon Io (643).

**117** τερμόνιον: At the world's end, isolation (*cf.* 1 f.). Ironical reference to τέρμα (n. 100)?

πάγον: n. 20. Was this word chosen to denote Prometheus' place of confinement because of its etymology?

**118** θεωρός: Prometheus' first guess, *cf.* nn. 69 and 91. The word implies a person, and προσέπτα is not inconsistent with the implication, for of Prometheus' visitors only Io approaches on the ground.

**119** ὁρᾶτε: carries on the assumption of θεωρός.

δεσμώτην: Source of the title (Schol.).

δύσποτμον θεόν: A paradox, for μακάρες οἱ θεοί, *cf.* nn. 96 and 198.

**120** Διὸς ἐχθρόν: Prometheus heard 67.

**120 f.** renew 37.

**122** αὐλὴν: The gods resort to Zeus' αὐλή as to a tyrant's court, *cf. Odyssey* 4.74 (Thomson) and Méautis, 79, n. 1, who remarks that Ocean is a type of the old and experienced courtier.

**123** λίαν: n. 72.

φιλότητα βροτῶν: *cf.* 11, 28.

**124** κινάθισμα: fluttering) (the rigidly motionless Prometheus. So κίνυγμα in 157.

**125** πέλας: To a man with many powerful enemies any approach is potentially dangerous; Prometheus' isolation contains an element of safety. πελάζω of menacing nearness: 153, 712, 807, 897.

οἰωνῶν: could refer to any winged creature, including the eagle.

αἰθὴρ: The scene of Prometheus' punishment, both when he is first confined (88, 113, 158, 280, 394) and at Zeus' final onslaught (1044, 1048, 1092). 88–92 and 1091 f. form a pair, framing the entire role of Prometheus, the god suspended in the limpid air. Prometheus both hates to be stared at by the curious who, like Solon, come κατὰ θεωρίης πρόφασιν, and enjoys having witnesses to the injustice of his punishment.

ἐλαφραῖς )(Prometheus' immobility and the tyrant's ponderousness (n. 17). So 263 and 279.

**126** ῥιπαῖς: With these ἐλαφραὶ ῥιπαί)( the ῥιπὴ of all nature in 1089.

ὑποσυρίζει: In 574 f. the buzzing of Io's gadfly is ironically compared to the notes of a σῦριγξ (δόναξ). Other menacing sounds: n. 115. To a helpless person every sound, even odor (115), no matter how harmless seemingly, is terrifying.

**127** Prometheus timid: n. 41.

PARODOS AND KOMMOS: 128–192

**128** μηδὲν φοβηθῇς: The Chorus show their sympathetic nature at the very outset by reassuring Prometheus, whose words (127) they heard.

**130** πάγον: n. 20.

**130 ff.** *Cf.* Nausicaa.

**132** κραιπνοφόροι: *cf.* κραιπνόσυτος of their winged car (279).

**133** κτύπου: Symbolic of Zeus' power, which is not all-supreme (916 and 923).

ἀχὼ: n. 115.

χάλυβος: *cf.* 715. Most of the items in Io's itinerary have connections elsewhere in the play.

διῆξεν: Why ἀίσσω? Perhaps because the maidens themselves are impetuous: θοαῖς (129), κραπνοφόροι (132), 135, προσῆξε (145).

ἄντρων μυχόν: Inhabited by Ocean and his daughters; in 453 of primitive man. Prometheus brought man up into the sunlight; the sound of Prometheus' chaining brought the Chorus and Ocean forth from their cave.

**134** ἐκ . . . ἔπληξε: The laying aside of their maidenly modesty was for them an upheaval comparable to what befell Typho (360). ἐκπλήσσω carries on κτύπος.

θεμερῶπιν αἰδῶ: *cf.* Nausicaa. Harry notes that the eye is the seat of αἰδώς: *cf.* nn. 141 ff.

**135** ἀπέδιλος: Denotes haste (Schol.) and emotion (Thomson in *CQ* **29**: 38, 1935). Surely the Chorus did not leave off their sandals because they had to dance on slippery rocks (Severyns).

**139** ἀκουμήτῳ: So Prometheus (32) and Io.

**140** δέρχθητ', ἐσίδεσθ': *cf.* 92 f. and n. 125. Prometheus is eager for friends to look and witness.

**141** οἵῳ δεσμῷ: *cf.* 92 f.

προσπορπατὸς: n. 61.

**142** φάραγγος: n. 15.

ἄκροις: Also in connection with Typho's punishment (366). Prometheus was extreme (n. 72, especially περισσόφρων 328), and his place of punishment is extreme (n. 18).

**143** φρουρὰν ἄζηλον: cf. 31.

**144** λεύσσω: The Chorus perform the witnessing that mute nature could not do so well (88–95).

φοβερὰ: becomes the Chorus better than Prometheus (127 and n. 41).

ὄσσοις: The seat of sympathy (*cf.* 145 ff.) and maidenly modesty (n. 134) as well as of hostility (53 f.) and idle or malicious curiosity (69, 118).

**145** προσῇξε: n. 133.

**146** εἰσιδούσῃ: ε(ἰ)σοράω 13 times in the play, of which six at Prometheus, two at Io. *Cf.* 152 ff.

**147** προσαυαινόμενον: recalls 22. It is day.

**148** ἀδαμαντοδέτοισι: n. 6. For the type of compound, *cf.* 580.

λύμαις: The Chorus, being sympathetic, term the fetters "outrageous maltreatment." Previously the metaphors for chains were all drawn from the sphere of animals (n. 81), except for ἀνάγκαις (n. 108) and τέχνης (n. 87). λύμη is not far from Prometheus' own judgment on his bonds (n. 93).

**149** : νέοι: n. 35.

οἰακονόμοι: *cf.* 515, where it turns out that the true pilot is not Zeus.

κρατοῦσ': characterizes the violent reign of Zeus, won by violent methods, against violent adversaries (429), maintained by violent means (167 and Cratos), and destined to be overthrown violently: 35, 149, 150, 213, 324, 403, 519, 527, 937, 939, 948, and 955.

**150** νεοχμοῖς . . . νόμοις: *cf.* Zeus' private, personal νόμοι at 187 f. and 403.

κρατύνει: *cf.* 403 and n. 149.

**149–151** Zeus came to power by overturning the established order, a crime that he now punishes in Prometheus. Zeus too was once a god against the gods (n. 29), and Prometheus helped him.

**151** τὰ πρὶν . . . πελώρια: The Titans, *cf.* μεγαλοσχήμονα at 408.

ἀιστοῖ: means primarily "destroys," makes to disappear by plunging in Hades, the unseen realm: *cf.* 232, 668. Admirable discussion of the word in this sense by Bacon in *CR* **42**: 116, 1928. ἀιστόω may also carry a secondary meaning, "make (appear as) nothing," "eclipse": "with novel laws Zeus establishes his despotic sway and makes the old abominations seem as nothing (in comparison with his new ones)," *cf.* 315 f.

**152** Ἄιδου: Prometheus picks up the Chorus' final word to express the wish that Zeus had relegated him to the unseen regions: *cf.* his dislike of being stared at in 69, 91, 118 f.

**153** νεκροδέγμονος: Prometheus, being immortal, would not be νεκρός )(Io's wishes in 582 ff., 747 ff.

ἀπέραντον: Again in 1078, when the Chorus resolve to share Prometheus' fate.

**153 f.** *Cf.* 582. Io is mortal, and longs for death as a release; Prometheus is immortal and wishes for release merely from the malice of his enemies. He suffers more in mind than in body (Méautis, 87, and n. 143 *sup.*). Prometheus' wish is repeated in stronger terms (e.g., ῥίψειε 1051—ἧκεν 154) at 1050–1053, and is fulfilled.

**154** ἀλύτοις: Prometheus would accept an eternity of private punishment in preference to aeons (δυσλύτοις 19) of public ridicule. The alternative interpretation of ἀλύτοις (viz., that Prometheus bluntly says what kindly Hephaestus avoided) is probably not valid, for at 175 ff. Prometheus speaks of the possibility of release.

**155** ἀγρίως: As befits a tyrant. ἄγριος is used of Prometheus' chains (175) and of the winds that Zeus lets loose against Prometheus (1046). But ἀγριότης is characteristic also of Zeus' opponent, the Titan Typho (368). Tyrants rise to power through a savage struggle with savage opponents.

πελάσας: n. 125.

**156** τις ἄλλος: Schol. remark that he avoids saying ἄνθρωπος. It is, in fact, inconceivable to him that any one of mortals, whom he benefited, should rejoice at his sufferings. Io, the only mortal who visits him, is completely sympathetic. Perhaps Aeschylus, in writing τις ἄλλος was thinking of Hermes, whom Prometheus treats, not as a god, but as a mere servant.

ἐγεγήθει: Prometheus fears ἐπιχαιρεκακία. At 760, if Murray's emendation of μαθεῖν to γαθεῖν is correct, Prometheus turns the tables on Zeus.

**157** αἰθέριον: n. 125.

κίνυγμ': Bitter irony, *cf.* n. 124.

**158** ἐπίχαρτα: *cf.* ἐπιχαιρεκακία, and 31.

πέπονθα: πάσχω 13 times, including the last word of the play, always with reference to Prometheus or Io. In a tyranny the tyrant alone is a free agent (50): he is active (939 f.), all others are passive.

**159** τλησικάρδιος: *cf.* 242 and Hephaestus' lack of τόλμα in 16 )( θράσος of various characters, n. 42. The Chorus refer to other gods, but it is Prometheus who is preeminently τλησικάρδιος, just as at 242 the modifiers really describe Prometheus.

**160** ἐπιχαρῆ: *cf.* 158.

**161 f.** Prometheus feels that all the gods are his enemies, as he has ample reason to do from the Prologue (e.g., 37), but the Chorus suggest that Zeus alone hates him.

**162** ἐπικότως: The wrath of Hera falls upon Io at 601.

**163** ἄγναμπτον: Prometheus (*cf.* Maddalena, p. 138) is equally inflexible (e.g., 995, 1001–1006). Prometheus' mental and physical states correspond (n. 18): the rigidity of his physical position is both the representation and the punishment of his rigid opposition to Zeus—*cf.* κάμπτειν in 32 and 396, 237, 306, 513. Inflexibility is one of the leading themes of the play, and it is the inflexibility not merely of the new gods, as del Grande supposes (*Hybris*, p. 453). See Index, *s.v.* ἄγναμπτος, ἀδαμάντινος, ἀδαμαντόδετος, ἀδήριτος, ἀεί, γυναικόμμος and θηλύνους, κραίνω, λήγω, λύω, λωφάω, μαλακογνώμων, μαλθακίζω, μαλθάσσω, μεθαρμόζω, πέτρα, στερρός, τέγγω, χαλάζω and χαλάω, τραχίς, and τραχύτης. Prometheus is as inflexible as Cratos and Zeus.

**164** δάμναται: Zeus dominates the gods as Hera does Io (601). See n. 6 on the implications of δαμ-. If Zeus ceases to exercise domination his tyranny will cease to be a tyranny and will become some other form of government.

**165** οὐδὲ λήξει: with ἀεί (162) expresses Zeus' inflexibility, *cf.* αἰεί in 26.

**165 f.** Logical analysis, as at 116. The Chorus can conceive but two reasons why Zeus would ever relent: he might become sated with his own cruelty, or he might be violently overthrown. It remains for Prometheus to suggest a third possibility in his reply (175–177).

κέαρ: Seven times in the play, of which four refer to Zeus: wrath (here and 390); inflexibility (here and 185); love (590), which proves cruel and destructive to Io.

**166** παλάμᾳ: foreshadows the παλαιστής of 920. δυσάλωτον: Not ἀνάλωτον, for the Chorus (Maddalena, p. 140) know of the fates of Uranus and Cronus.

ἀρχάν: Always of Zeus in the play—231, 757.

**167–169** Prometheus begins the gradual revelation of the hold that he has over Zeus: 188, 515–525, 755 f., 908 ff. (Groeneboom).

**168 f.** αἰκιζομένου . . . μακάρων πρύτανις: n. 96. But Prometheus' mood is changing (zum Felde, p. 24): he is growing more confident in the kindly presence of the Chorus.

αἰκιζομένου: n. 93.

**170** δεῖξαι: Because of his foreknowledge Prometheus acts as a revealer to Zeus (here and 914), to Io (607, 623), and to man (458, 482).

νέον: n. 35. Zeus, who overthrew Cronus by a revolution, will be exposed to νεωτερισμός himself, through his own folly (762)—ἴσα πρὸς ἴσα.

βούλευμ': The decision of Zeus to unite with Thetis (Schol.). Zeus plots (619), but will be overthrown by his own plots (762). Zeus will need Prometheus in the future (914) as he needed him in the past (219–222).

**171** *Cf.* 761. Verses 757–774 are an expansion and clarification of 167–177.

σκῆπτρον: The symbol of royal power, as in 761.

τιμάς: n. 30.

ἀποσυλᾶται: Prometheus has already filched (83) a number of the gods' τιμαί, and Zeus is destined to lose his sceptre, which implies that he will cease to be a monarch.

**172–175** Zeus can neither cozen (Thomson, 9, *sub fin.*) nor terrify Prometheus into revealing the νέον βούλευμα: *cf.* 959–963, 987–997.

**172** μελιγλώσσοις: Ocean is the only character in the play who uses flattery, though he denies (293 f.) that he is doing so; all the rest are remarkably plain-spoken—see Index, *s.v.* αἴνιγμα, αἰνικτηρίως, ἁπλοῦς, ἄσημος, δυσεύρετος, δύσκριτος, δυσκρίτως, and *cf.* 78.

πειθοῖς: The opposite of πειθώ is βία (Schol.). μελίγλωσσος πειθώ is characteristic of democracy, not tyranny: the persuasion of tyrants (669) is a mockery, for a tyrant can scarcely be persuaded (333). The persuasions of Hermes are threats (1014, 1064).

**173** θέλξει: Flattery cannot cast a spell, but true love can (865). Hypermestra is thus a lesson to Zeus.

στερεάς: The threats of Zeus are like the power of ἀνάγκη (1052); and, by implication, like the rock and like Prometheus himself (n. 163).

**174** πτήξας: *Cf.* 29, 960, and the mood of 1002–1006.

**175** καταμηνύσω: Prometheus as revealer, n. 170.

**175–177** Prometheus' answer to the Chorus (166 f.) ends with the same type of clause, but he adds a third and strikingly different possibility to the two proposed by them: Zeus may one day voluntarily relinquish tyranny and choose the right.

ἀγρίων: n. 155.

**176** χαλάσῃ: In 58 Cratos believed that Prometheus was being bound for eternity.

ποινάς . . . τίνειν: n. 112.

**177** αἰκείας: n. 93.

ἐθελήσῃ: A striking word, looking to Zeus' reform. Zeus must not only atone for the wrong done Prometheus, but he must do it willingly: so 190–192. The friendship of Zeus and Prometheus could be restored to its previous basis (*cf.* 218). This solution to the struggle between the two (viz., a voluntary rapprochement from both sides) is lost to view after the beginning of the play as Prometheus' indignation mounts and he grows increasingly intractable. How difficult such a voluntary change would be for Zeus is illustrated by 1067.

**178** θρασύς: The Chorus are astonished at Prometheus' suggestion: *cf.* n. 42. Hypermestra (861) illustrates what can come of voluntarily (βουλήσεται 867, *cf.* ἐθελήσῃ 177) renouncing θράσος, even when it is justified.

πικραῖς: Zeus has been vindictive to both Prometheus (195) and Io (739), and Prometheus reacts in the same spirit (944). The Chorus condemn Zeus' harshness, but question neither his right nor his power to act as he will.

**179** δύασιν: Of Prometheus 513, 525; of Io 746. At 513 and 525 escape is in sight.

ἐπιχαλᾷς: *cf.* 176. Prometheus is as unyielding as his bonds and as Cratos (58).

**180** ἄγαν: n. 72. The Chorus characterize Prometheus also in 260 ff., 543 ff., 1036 ff., always in a gentle and kindly spirit, but firmly.

ἐλευθεροστομεῖς: The gloss given in the Schol. (παρρησιάζει) clearly brings out the implications of the word: Prometheus is living under a tyranny (50), but acts as if he were in a democracy (n. 172). Ocean calls Prometheus ὑψήγορος (318), and Typho was too (360). Prometheus is now bound hand and foot, but his tongue is still free. *Cf.* Ocean's warning, 327–329.

**181** ἠρέθισε: Used metaphorically of the aether in 1045.

διάτορος: In 76 the chains cut into Prometheus, and the wedge pierces him literally. This word indicates the Chorus' intense sympathy for Prometheus' physical sufferings.

**182** δέδια: *cf.* 144, 902, and n. 41. The Chorus are timorous maidens, and their sudden burst of courage (1063–1070) is surprising.

**184** τέρμα: n. 100.

κέλσαντ': n. 15. The end of Prometheus' sufferings is conceived as a haven where he will find rest from the storm of Zeus' wrath, which afflicts Io also (746).

ἐσιδεῖν: not ἐσελθεῖν. The mere sight of a safe harbor brings greater joy to the mariner than the actual arrival.

ἀκίχητα: Zeus' ways are past finding out because he is completely free (50) and irresponsible (324), using only his own private laws (150, 186 f.).

**185** κέαρ: n. 166.

ἀπαράμυθον:)(δυσπαραίτητοι in 34. Similar change in δυσλύτοις 19 and ἀλύτοις 155: Hephaestus was kindly, while the Chorus are discouraged and fearful. Zeus, in the Chorus' opinion, is adamantine; and because he is adamantine they regard Prometheus' suggestion (175–177) as utterly impossible of fulfilment.

**186** οἶδ': Also of Prometheus at 328, 504, 607, 915, 1040. Prometheus is proud of his knowledge: nn. 10 and 62. He needs no instruction from the Chorus.

τραχὺς: n. 35.

**186 f.** παρ' ἑαυτῷ τὸ δίκαιον ἔχων: *cf.* 403. Law and justice are in the keeping of the tyrant, not available to all as in a democracy.

**187** οἴω: Here lurks Prometheus' ἐπιχαιρεκακία (Harry): *cf.* 156–161.

**188** μαλακογνώμων) (the typical hardness of the tyrant, n. 79. Hermes denies (952) any softness in Zeus, but Prometheus vows (1003) that he too will never become θηλύνους. Prometheus and Zeus are equally hard and inflexible: nn. 35, 42, 64, 80, 163. The only possible reconciliation would require concessions on both sides (191 f.), a possibility mentioned by Prometheus at 175–

177 )(166 f. Kitto in *JHS* **54**: 19, 1934, Peretti in *Antike* **20**: 23 ff., 1944, and in *Maia* **4**: 14 ff., 1951, and others consider this the only possible solution of the conflict.

**189** ῥαισθῇ: n. 56. Prometheus conceives the softening of Zeus as a voluntary change of policy following a violent attack upon Zeus' sovereignty.

**190** ἀτέραμνον: Zeus' merciless wrath is manifested in thunder (1062).

στορέσας: )(κορέσῃ 166. The Chorus believe that Zeus' wrath will cease only when Zeus is satisfied )(189. Prometheus and Io are both storm-tossed by Zeus' anger (n. 15 and 183); Prometheus suggests that Zeus might calm the storm (conciliation).

ὀργὴν: n. 80.

**191** ἀρθμὸν: )(the ἀρθμός in which Prometheus finds himself (60). φιλότητα: )(στέργειν in 11. True reconciliation and friendship )(the violent subjugation of one who remains at heart an enemy. If Zeus should enter into φιλότης with Prometheus it would show that the reconciliation was completely genuine, for Zeus' hatred of Prometheus arose because of another sort of φιλότης (123). *Cf.* n. 546.

**192** σπεύδων σπεύδοντι: The converse of the anadiplosis of θεός (n. 29). Prometheus and Zeus would stand side by side as they did in the past (218), in a free and unconstrained (*cf.* ἐθελήσῃ 177) relationship, the converse of that referred to at 19 (Groeneboom).

FIRST EPISODE: 193–396

**193** ἐκκάλιψον: Prometheus is the revealer—10, 59, 62, 86 f., 101–103, 110, 170, 175, and διδάσκω in 196, 382, 634.

γέγων': γεγων- occurs eight times in the play, seven with reference to Prometheus, thus emphasizing his function as a revealer: *cf.* 523, 627, 657 (of Io), 784, 787, 820, 990.

**194** αἰτιάματι: charge, accusation. *Cf.* 226, 255. This word, together with ἀτίμως and αἰκίζεται in the next verse, carries us into the realm of Attic law.

**195** ἀτίμως: suggests ἀτιμία—Prometheus is deprived of his rights and status as a god. Once again the punishment suits the crime (n. 18): Prometheus loses his own τιμαί because he stole the gods' for men. In 919 Prometheus turns the word against Zeus: ἴσα πρὸς ἴσα.

πικρῶς: n. 178.

αἰκίζεται: n. 93.

**196** δίδαξον: *cf.* ἐκκάλιψον (193).

βλάπτῃ: The Chorus, though inquisitive as will appear further below (631 ff.), are considerate. The damage to Prometheus could be internal or external (*cf.* Ocean's warning at 311–314). Prometheus takes it in the former sense—another proof that his mental sufferings are more important than his physical. *Cf.* 763. Zeus is offended, in fact, not that Prometheus speaks, but that he does not reveal more (947–950).

**197 f.** *Cf.* 106 f. and 238.

**198** δύσποτμα: n. 119.

**199–225** Before answering the Chorus' question (194) Prometheus digresses on the ingratitude of Zeus, thus tending to create a prejudice against Zeus at the very outset and to palliate Prometheus' offence; but the latter objective is not a very real one—at least it is attained in the eyes neither of the Chorus (259–261) nor of Prometheus (266).

**199** δαίμονες: The gods and the Titans.

χόλου: Wrath is a source of στάσις, and a characteristic of all the Titans (n. 80), not of Zeus merely (n. 162).

**200** στάσις: The political life of the gods parallels that of men: Zeus is a tyrant who rose to power as a result of party strife: *cf.* Nestle, 28. στάσις occurs in nature too: 1087.

**201** ἐκβαλεῖν: Another political term, which Prometheus turns against Zeus in 910. *Cf.* its virtual passive, ἐκπίπτω (ἐκπίτνω), in the Index.

ἕδρας: = θρόνου. *Cf.* 389. Throughout the play Prometheus has the notion that Zeus will fall as he made Cronus fall, and that Zeus will be punished as he is punishing Prometheus.

**202** ἀνάσσοις: The nature of Zeus' regime is made clear at 584, where his suffering victim, Io, calls upon him by the title ἄναξ to let her die.

**202 f.** τοὔμπαλιν σπεύδοντες: The converse of σπεύδων σπεύδοντι in 192. The reconciliation of Zeus and Prometheus would be the complete negation of στάσις.

**203** ἄρξειεν: *cf.* n. 167. ἄρχω is used in two other passages of Zeus' reign (927, 940), both times with a view to its termination. ἀρχή is used only of Zeus.

**204** τὰ λῷστα . . . πιθεῖν: As in a democracy, n. 172. At 307 f. Prometheus himself receives advice from Ocean; and at the end of the play, as Thomson remarks, Prometheus turns a deaf ear to good advice.

**206** αἰμύλας . . . μηχανὰς: Characteristic of Prometheus, n. 59.

**207** ἀτιμάσαντες: *cf.* ἀτίμως, 195. Since Prometheus prides himself on his mental powers, especially as displayed in the functions of prophet and teacher, it was a grievous insult to him that the Titans scorned his advice. While the Chorus term his present punishment ἀτιμία, Prometheus applies the word to the Titans' scorn.

καρτεροῖς: )(αἰμύλας. The contest between intelligence (craft) and power is exemplified in the struggle between Zeus and Prometheus. The two should not and cannot be completely divorced from one another: i.e., Zeus does not represent mere power; nor Prometheus, undiluted intelligence. Zeus came to power only with the help of Prometheus' intelligence (219–221); and Prometheus can hope for release only if Zeus some day learns or is taught to temper his violence with intelligence (190–192). If Prometheus and Zeus should be reconciled, Prometheus would still be intelligent but no longer powerless, while Zeus would still be powerful, but also wiser.

The Titans were violent in thought, but also in action (212 f.). Zeus overcame them by guile (219); but, like them, he now puts his trust in brute strength, symbolized by the thunderbolt (καρτερὸν κτύπον, 923), the power of which Prometheus believes may one day be surpassed. Intelligence surpasses power. That is Prometheus' belief, and he illustrates it by the story of the Titans' fall. At this point of the play Prometheus, being concerned to prove Zeus' ingratitude, does not suggest that Zeus may become the victim of violence like the Titans. This suggestion is reserved till later, when Prometheus has witnessed the shocking use of Zeus' power against Io.

Cratos and Bia embody Zeus' trust in his power, a trust once felt by the Titans (καρτεροῖς . . . πρὸς βίαν, 207 f.).

**208** ἀμοχθί: Yet the Titans suffer μόχθοι—Atlas' and Typho's are described 347–372, 425–430; Prometheus' are alluded to at 99, 244, 314, 541, 756, 1026.

πρὸς βίαν: n. 74.

δεσπόσειν: Zeus is fated to be mastered (930), according to Prometheus.

**211** κρανοῖτο: The verb recurs twice, with increasingly clear reference to the fall of Zeus: 512 refers to the decrees of Moira, whose power is above Zeus'; 911 suggests that Cronus' curse upon Zeus will be fulfilled. Here Prometheus does not speak of Zeus' fall (*cf.* n. 207), though he may have begun to think of it.

προυτεθεσπίκει: *cf.* 101 f. Prometheus' prophetic powers came to him from Themis.

**212 f.** κατ'ἰσχὺν . . . πρὸς τὸ καρτερὸν . . . δόλῳ: renew the points of 206–208 in reverse order.

**213** κρατεῖν: The aim of στάσις. At the beginning of the play Zeus has the power (35, 149, 324), having outwitted the Titans with Prometheus' aid. Verse 519 is the turning point: Zeus will lose his power (937, 939, 948). *Cf.* a similar progression in the use of πατήρ, n. 4.

**214** ἐξηγουμένου: 446, 702. The only instance in the play of Prometheus' teaching proving unsuccessful )(his dealings with primitive man, Ocean, Io, and the Chorus. He does not try to teach Hermes.

**215** ἠξίωσαν: n. 240.

οὐδὲ προσβλέψαι: Prometheus was offended that the Titans would not so much as glance at his advice. Ignoring can be as offensive as staring: nn. 69, 91, 118, 141, 143, 144.

**218** ἐκόνθ' ἑκόντι: n. 192. Converse of anadiplosis of θεός: the gods should cooperate.

συμπαραστατεῖν: join the party (στάσις) of Zeus. *Cf.* συγκαταστήσαντα, 305.

**219** βουλαῖς: Themis was ὀρθόβουλος (18), but her son's βουλαί led to disastrous consequences for himself and his brothers. Hermes is justified when he counsels Prometheus to cultivate εὐβουλία (1035).

**219 f.** Cronus is where Prometheus wished, in a moment of weakness, that he might be (152 f.). *Cf.* 1029, 1051.

**221** συμμάχοισι: οἱ Κρόνῳ συμπαραστατοῦντες (*cf.* 218).

**222** τύραννος: n. 10. At 957 of Uranus and Cronus; elsewhere of Zeus, see Index *s.v.* τυραννίς, τύραννος.

ὠφελημένος: Prometheus was a helper *par excellence*. ὠφελημένος generalizes συμπαραστατεῖν (218). Prometheus helped Zeus, who is un-

grateful (223); and he helped man (251, 501, 507, 613), who can do nothing for him (267, *cf.* 547). Theme of lost labor: 44, 340–343.

**224 f.** Distrust is the disease of tyranny. Surely this play was not produced at the court of Hiero. *Cf.* Io's maxim based on a disease metaphor (685 f.).

**225** *νόσημα*: The disease metaphors are collected by Thomson, p. 11, n. 2; first adequately discussed by Fowler (*op. cit.*, n. 43 *sup.*).

*πεποιθέναι*: Under a tyranny trust is as misplaced as persuasion is useless (n. 172).

**226** Prometheus ends his digression on the ingratitude of Zeus and returns to the question asked by the Chorus in 193–196. *αἰτία* replaces *αἴτιαμα* (194).

**227** *αἰκίζεται*: 195.

*σαφηνιῶ*: *σαφ-* nine times of Prometheus, once of Io (641, where she is inspired by Prometheus); *σαφῶς* at 664 of Apollo's oracle to Inachus. Prometheus is the oracle in this play and his procedures, as we shall see, are Delphic.

**228** *πατρῷον ἐς θρόνον*: An ominous seat (n. 201). This whole clause, which could be used of peaceful succession among mortals, emphasizes the treachery involved when it is applied to immortals.

**229** *νέμει*: *cf.* *ὁ πάντα νέμων*, 526.

*γέρα*: n. 38. These prerogatives were in the gift of Zeus, not of Prometheus. On 439, which is superficially inconsistent, see n. there.

**231** *βροτῶν*: )(*δαίμοσιν*, n. 8. *βροτοί* were one of the two parts of Zeus' realm, but Zeus ignored them. Vandvik's suggestion (34) is bizarre that Zeus wished merely to establish *νέοι τρόποι* in men, not to destroy them.

*ταλαιπώρων*: At 315 applied to Prometheus by Ocean, using a sympathetic approach to mask some unpalatable advice. Io twice (595, 623) uses the word of herself, but she is full of self-pity, while Prometheus also pities men (239).

**232** *ἀνιστώσας*: Zeus' trusted technique, applied to the Titans (n. 151), especially Atlas and Typho, and used as a threat against the family of Inachus (668). The threat is turned against Zeus in 910: *ἴσα πρὸς ἴσα*. )(Genesis 6: 7. Zeus was prompted by mere caprice, the desire to make a complete sweep. Thomson suggests a flood, but *διαρραισθέντας* (236) seems to indicate the thunderbolt.

**233** *ἔχρῃζεν*: *cf.* 738, 984. Zeus' purposes are self-seeking and heartless.

*νέον*: A new human race, new gods (n. 35), new *νόμοι* (149): a new order.

**234** *οὐδείς . . . πλὴν ἐμοῦ*: Prometheus' second unique action, though at 216 ff. he was prompted and joined by Themis. Here he stands alone against the new order because of his pity for men; and here begins the struggle *θεός vs. θεοί* (n. 29). On *πλήν*: n. 913 f.

**235** *ἐτόλμησ'*: Prometheus prides himself on his *τόλμα*, as appears especially in his interview with Ocean: 299, 331, 381. )(Hephaestus at 14. *Cf.* n. 42 on *θράσος*.

*ἐξελυσάμην*: Ocean abandons his attempt to save Prometheus (326, 339), but Prometheus will still be saved (781), though not by men (n. 222).

**236** *διαρραισθέντας*: *cf.* nn. 232 and 189. Zeus might have attacked men as he has Prometheus.

*Ἅιδου*: renews *ἀνιστώσας* (232). Prometheus saved men from the fate that Atlas and Typho have already suffered and he himself will suffer (1018): not confinement in Hades in the narrow sense, but relegation to an *unseen* region.

**237** *πημοναῖσι*: Six times of Prometheus, twice of Io, once of Ocean, once in a maxim, the latter two passages being spoken by Prometheus, who has every reason to be more aware of *πημονή* than others are.

*κάμπτομαι*: Ironical, for Prometheus is bent neither in body nor in mind, n. 163.

**238** *Cf.* n. 106 f.

*ἀλγειναῖσιν*: *cf.* 197.

*οἰκτραῖσιν*: Of Atlas' woes in 435.

*ἰδεῖν*: Chorus are looking at Prometheus with pity, not malice )(152–157.

**239** *οἴκτῳ*: Distinguished Prometheus from Zeus, who is pitiless: *cf.* Maddalena, 139. Pity permeates 238–240: *οἰκτραῖσιν, οἴκτῳ, τοὐτου* (*sc.* *οἴκτου*), *νηλεῶς*.

**239–241** As at 221–223 Prometheus comments on Zeus' failure to reciprocate )(175–177, 191 f. Todd (65) compares Creon's attitude to Antigone.

*νηλεῶς*: Recalls Cratos (42), Zeus' minion.

*ἠξιώθην*: *Cf.* 215. Prometheus feels unappreciated both by the Titans and by Zeus.

*ἐρρίθμισμαι*: Dumortier, *Images*, 59, compares *Persae* 747. The metaphor suggests the teacher

taught, as in 10 and 62. Is there a reference to the rhythmical blows of Hephaestus' hammer? Schol. identify the metaphor as tuning of the lyre.

δυσκλεὴς θέα: *Cf.* Hesiod, *Th.* 530 ff. and Solmsen, 148 f. Looking is not always an evil: the spectacle of Prometheus' punishment will damage Zeus' reputation. This thought may prompt Prometheus' calling on the elements to witness: 88–97, 1091–1093.

**242–244** *Cf.* 160–163.

σιδηρόφρων and ἐκ πέτρας εἰργασμένος: like τλησικάρδιος (n. 160), ostensibly characterize unsympathetic spectators of Prometheus' sufferings, but in fact suit Prometheus (and Zeus). Prometheus, the revealer of iron to men (502), is the man of iron chained with steel fetters (the superficial meaning of ἀδαμάντινος); the man of rock, chained to a rock. *Cf.* n. 163 on inflexibility.

συνασχαλᾷ: *cf.* 162. Prometheus receives from the Chorus the sympathy that he gave to man, but which they cannot give him in return because of his isolation (n. 2).

εἰσιδεῖν: *cf.* θέα (241), 141, 146. If the Chorus had known the gravity of Prometheus' μόχθοι, they would not have come to look at him.

**245** ἔξηγζον: )(the wishes of Zeus, n. 233.

ἠλγύνθην: )(the ἐπιχαιρεκακία of 152–163. Prometheus considers pain the appropriate emotion: 197, 238.

κέαρ: n. 166 on the heart of Zeus.

**246** φίλοις ἐλεινὸς: )(152–163. Prometheus is a mirror to his visitors, showing most self-pity before those who pity most. φίλοις is emphatic )(37, 120, 159.

ἐλεινὸς: *cf.* 239 f. Zeus feels no pity for Prometheus, nor did Cratos.

εἰσορᾶν: Used of Prometheus at 141, 146, 244, 245, 245, 1093.

**247** περαιτέρω: *cf.* πέρα δίκης (29). Not only farther, but too far.

**248** προδέρκεσθαι: δέρκομαι (*cf.* 54, 93, 141) connects with the triple use of ἐσοράω in 244–246. προδέρκομαι suggests Prometheus' name. He can foresee the future, including all the pains and torments that are in store for him, to which death can never put an end: 101–103, 843.

μόρον: death. Vandvik (44 f.) translates, "think beforehand of their allotment," i.e., worry about livelihood; but see Fraenkel on *Agamemnon* 1146. Perhaps primitive man was believed to have premonitions of his death as animals do.

**249** εὐρών: n. 59.

φάρμακον νόσου: The fearful expectation of death is a disease, n. 225.

**250** τυφλὰς: Paradoxically, Prometheus also gave sight to the blind: 447, 499.

ἐλπίδας: A great aid to life (538). The Chorus believe that there is no hope for Prometheus (259).

κατῴκισα: planted like a colony. Prometheus' hope of release lies in the colony (814) that Io will found in Egypt.

**251** ὠφέλημα: n. 222.

ἐδωρήσω: Gifts of Prometheus to Io—616, 626, 778. Gifts do not come from tyrants (338 and n. 583). *Cf.* also δίδωμι 446, 779 f., 822; δοτήρ 612; ὀπάζω, n. 8. Prometheus is a δοτὴρ ἐάων, as all the gods are supposed to be.

**252** πῦρ: Prometheus names fire third, *cf.* n. 7. ὤπασα: n. 8.

**253 f.** The Chorus describe fire with a conventional, pictorial adjective; to Prometheus fire is important for what it makes possible: *cf.* nn. 7 and 10.

ἐκμαθήσονται: *cf.* 706, 776, 817, 876, all used of Prometheus' instructions to Io.

**255 f.** renew 194 f. "The word χαλᾷ is characteristic of Prometheus": Schol. True; but the scholiasts might have carried this sort of observation farther with profit.

**257 f.** ἄθλου: n. 95.

τέρμα: n. 100. *Cf.* 755 f., where προκείμενον also recurs. Here Prometheus states that his future hangs upon Zeus' caprice (*cf.* 233); at 755 f. he implies that Zeus may be overthrown.

δοκῇ: *cf.* nn. 177 and 233 on the will of Zeus, who is a law unto himself in the opinions of Cratos (50) and Ocean (324). *Cf.* n. 755.

**259** ἐλπίς: n. 250.

**260** ἥμαρτες: The Chorus share the view of Cratos (n. 9), though they sympathize like Hephaestus. Prometheus' pity caused his sin, and Zeus' justice causes his according to Maddalena, 139 f. But observe that Zeus is never called just in the play, nor is he said to have sinned; he is merely described as a tyrant.

Justice is one of the great themes of the *Oresteia*, not of *Prometheus*: nn. 9 and 30.

**260 f.** *Cf.* the form of 106 f., 197 f., 238.

**262** ἄθλου: as in 257.

ἔκλυσιν: n. 235.

ζήτει: So Ocean in 316. Prometheus must not abandon himself to despair, a thought later elaborated in the simile of the ill physician, 472 ff.

**263** ἐλαφρὸν: n. 125. The Chorus are airy, volatile (n. 133) maidens, who have flown to him in a winged car.

**263 f.** πημάτων ἔξω πόδα ἔχει: Prometheus is caught in a net (81), and the Chorus will join him in the net of doom at 1078 f.

**264** ἔχει παραινεῖν: Platnauer, in *CR* N.S. **4**: 207 f., 1954, would read ἔχων παραινεῖ, with no change of meaning.

παραινεῖν: Their father Ocean does so at 307, and Hermes tries it in 1007–1035.

τοὺς κακῶς πράσσοντας: *cf.* 695 (Io), 971 and 979 (Prometheus). εὖ παθόντες (976) expresses the normal state of the gods, to which Prometheus is an exception.

**265** Prometheus knew full well what he was doing: his sin was voluntary, and he did not repent of it. The play never shows us Prometheus in a dilemma between two duties.

**266** ἑκὼν ἑκών: Prometheus echoes the Chorus' repetition in 260. He was utterly self-willed (like Zeus, 50). His sin was an error of will, not of judgment: Pohlenz II, 20. Once before, the will of Prometheus coincided with Zeus' (218), and it might again (192).

ἥμαρτον: Prometheus agrees with the Chorus (260 and n.9) and with Zeus, whose view is expressed by Hermes in 945.

**267** ἀρήγων: Men cannot help him (547). Whole verse sim. 239–241.

αὐτὸς: emphasizes the irony of the outcome, as in 762, where it is applied to Zeus.

ηὑρόμην: The ironical result of Prometheus' εὑρήματα for men: n. 59. Underlying the play there are a number of crucial and difficult decisions: the decision of Prometheus to place pity for men above fear of Zeus; the decision of Hypermestra to spare her husband (865–868); the decision of the Chorus to stand by Prometheus (1063–1070); and, in the sequel, the decision of Zeus to free Prometheus.

πόνους: *cf.* n. 46. Of Prometheus at 66, 84, 118, 182, 267, 282, 298, 326, 339, 615, 1027; of Cratos, 46; of Hephaestus, 75; of Atlas, 425; of Io, 684, 749, 776, 780, 872, 900; of Zeus, 931.

**268** ποιναῖς: n. 112.

τοίαισι: illuminates 92 ff. Prometheus regards his punishment as excessive; later, as unjustified. While the evidence either way is slight, I believe that del Grande (100) is mistaken in attributing the latter feeling to the whole play. Prometheus knew that his benefactions to man would be a sin in the eyes of Zeus and he expected to be punished (*cf.* 265), but not so severely: nn. 92 and 93.

**269** πεδαρσίοις: *cf.* 4 f., and n. 18.

**270** ἐρήμου: n. 2.

ἀγείτονος: n. 2.

**271** τὰ . . . παρόντα: Other woes are to come, of which Prometheus knows full well (98–103, 272). Both Prometheus and Io are in the midst of their troubles, especially the latter: 625, and observe the use of τὰ λοιπά with reference to Io at 634, 684, 697, 699, 703, 744 f., 780, 784, 819, and 844. There is extraordinary emphasis on Io's being in midstream, but her future is not completely dark: 835, 839. Prometheus' ultimate fate is uncertain throughout the play.

**272** προσερπούσας: *cf.* 127, but Prometheus does not speak again of fear until the very end of the play (1090). He alludes to his προσέρπουσαι τύχαι again in 511 ff. *Cf.* 1024.

τύχας: n. 106 f. Of Prometheus in 106, 182, 272, 288, 302, 347, 375, 398, 554.

**273** μάθητε: Prometheus is usually the teacher )(62. At 926 even Zeus learns.

τέλους: *cf.* n. 100 on τέρμα. Prometheus relates his own future unflinchingly to the Chorus; he is pained to reveal Io's to her (742–756).

**274** πίθεσθε: )(224 f. The relationship between Prometheus and the Chorus is of a type not possible for a tyrant, *cf.* 335 and n. 172. Prometheus cries out in a loud voice (277).

συμπονήσατε: The Chorus have a weakening effect upon Prometheus (n. 246), who calls for sympathy from the sympathetic Oceanids )(his relation to Hermes. συμπονήσατε, "share vicariously my πόνοι" (*cf.* 267).

**275** μογοῦντι: μογ- of Io, 565, 594, 603. πλανωμένη: *cf.* Io (n. 565).

**276** προσιζάνει: The image in this and the preceding verse is of a winged monster, flying in wide circles and then settling on its prey: Groeneboom. *Cf.* Prometheus' eagle. At 1024 ἕρπων . . . πανήμερος is reminiscent of πλανωμένη (275).

**277** ἀκούσαις: The Chorus share the sympathetic attitude of Hephaestus (19).

ἐπεθωύξας: Prometheus shares (also in 393) the strident character with Cratos (73) and Hermes (1041). Hiltbrunner, 76, finds the repetition pointless; but tyrant, henchmen and victim tend to become alike: nn. 155, 160, 163, 172, 173, 178, 180, 186, 188, 199, 207, 242–244.

**279** ἐλαφρῷ: *cf.* nn. 125 and 263. Carries on the dog image from ἐπεθώυξας. ἐλαφρῷ ποδὶ renews ἐλαφρὸν . . . πόδα in 263: i.e., the Chorus accept the fact that they are free and Prometheus is bound and willingly leave their winged car, the counterpart of their own unfettered impetuosity, to stand by Prometheus, literally and metaphorically (*cf.* συμπαραστατεῖν, 218).

ποδὶ: Only of Chorus (263, 279) and Io (712); their rushing is free, hers constrained.

κραιπνόσυτον: The swiftness of their car is comparable to that of the winds of heaven (132). *Cf.* n. 133 on the swiftness of the maidens.

**280** αἰθέρα: n. 88.

**281** οἰωνῶν: *cf.* 125, 129.

**282** πελῶ: *cf.* n. 125.

**282 f.** Their answer to 273.

χρῄζω: *cf.* 245.

**284–396** In this scene Ocean and his daughters take no notice of each other. Perhaps, as Pohlenz suggests, the Chorus withdrew to where Ocean could not see them. Be that as it may, the important point is that Prometheus is the center of attention throughout the play (Thomson).

The role of Ocean has been variously interpreted. Patin, who has found a few followers, was the first to find Ocean comic. Vandvik, 45, considers him "noble and engaging." On Ocean as a courtier, *cf.* n. 122.

**284** δολιχῆς: Ocean emphasizes Prometheus' remoteness (n. 2) and his own benevolence, but his toils are as nothing compared to those of Prometheus and Io, who one day will attain δολιχῆς τέρμα κελεύθου (n. 100). Ocean's journey is long in comparison with his daughters', who were within earshot of Prometheus' chaining (132–134); and Cammelli (40) points out that any journey might seem long to Ocean, since he may never have taken a long trip before, *Iliad* 20.7–9.

τέρμα: n. 100.

κελεύθου: Used of the journeys of Io (723, 837) and Hermes (962). Prometheus sends Ocean and Hermes back where they came from, while to Io he gives helpful instructions.

**286** πτερυγωκῆ: Ocean's mode of transport, whatever it is, is analogous to his daughters' (135).

οἰωνὸν: Variously identified as a winged horse, a griffin (Schol.), a flying fish (Thomson). List in Groeneboom, 146 f. and n. 152. *Cf.* n. 395.

**287** γνώμῃ: *cf.* the Phaeacians' ships, *Odyssey* 8.559. γνώμη distinguishes gods from primitive man (456), into whose life Prometheus introduced it (443 f.).

στομίων ἄτερ: )(Prometheus in 1009. Ocean treats his οἰωνός better than Zeus treats Prometheus: *cf.* 23, 32, 395 f.

εἰθύνων: *cf.* 324. Ocean directs his steed by democratic methods, whereas Zeus uses the στόμιον of tyranny (1009) to bring Prometheus to account.

**288** The tone of this line resembles the tone of the Chorus (e.g., 244 f.), but ἴσθι casts a shade of doubt on Ocean's sincerity (Harry), for one says ἴσθι when one expects not to be believed. δοκῶ in the next verse may have a similar effect.

**289** τὸ . . . ξυγγενὲς: influenced Hephaestus in 14 and 39, and the Chorus speak of their kinship with Prometheus at 555–560; but the fear of Zeus is stronger. Prometheus, in his dealings with men, was influenced neither by τὸ ξυγγενές (*cf.* anadiplosis of θεός), nor by fear of Zeus.

**290** ἐσαναγκάζει: *cf.* n. 16. Ocean's allusion to ἀνάγκη casts an ironical light on his character, for ἀνάγκη compels him to feel sympathy with Prometheus; but Prometheus easily dissuades him from taking action, whereas Prometheus and even Zeus himself are truly in the bonds of ἀνάγκη.

**292** μοῖραν νείμαιμ': portion at a feast, as in 631.

**293** γνώσῃ: *cf.* 309, 377. Ocean assumes the role of a teacher to Prometheus, though Pro-

metheus is *par excellence* the teacher: n. 193. So also when Ocean uses the word ἔτυμ': *cf.* n. 595. μάτην: is thrown back at Ocean in 342.

**294** χαριτογλωσσεῖν: *cf.* nn. 172, 173. Ocean claims the bluntness of Prometheus (180), though he later criticizes Prometheus for it (318 f.). The characters of the play are remarkably outspoken, especially Prometheus (whose tongue alone is free), but there is some χαριτογλωσσεῖν at the beginning: Hephaestus, Chorus and Ocean; and Prometheus himself shows consideration towards Io. Ocean's disclaimer of χαριτογλωσσεῖν is its deathblow, for the remainder of the scene shows mounting annoyance and anger.

ἔνι: inherent, *cf.* 224. If Méautis' interpretation of Ocean as an adroit courtier is correct, then this statement must be quite false.

**295** σήμαιν': *cf.* 565, 618, 684, 763, all addressed to Prometheus the revealer, *cf.* n. 193. Prometheus' answers to these five requests grow progressively more important, the last answer being the revelation of the threat that hangs over Zeus' head.

συμπράσσειν: is the natural result of τὸ ξυγγενές, but it never follows in *P.V.*: Hephaestus chains Prometheus, Ocean does nothing for him, 49 Danaids slew their cousins (855), and Prometheus betrayed the prerogatives of his kindred gods to men. What cooperation is mentioned in the play (συμπαραστατέω 218 and συγκαθίστημι 305, of Prometheus' helping Zeus to power; συναίρω 650, of Io and Zeus) leads to dreadful consequences, for no good can come of cooperating with a tyrant, as Prometheus tells Ocean (304–306).

**297** φίλος: Ocean is not truly Prometheus' friend. His daughters declare their friendship for Prometheus at their first appearance (128, *cf.* 546) and prove their friendship at the crisis of 1063 ff. Ocean thus turns out to be weaker than his daughters.

βεβαιότερος: The firm friendship of the play is Prometheus' for man (123).

**298** πόνων: n. 267.

**299** ἐπόπτης: 69, 91 ff., 118, 141, 146, 151 f.; 302, 304.

ἐτόλμησας: While visiting Prometheus, Ocean is shirking his duty: *cf.* ἄσβεστον (532). Prometheus adopts the same tone towards Ocean that Cratos used towards Hephaestus (14).

**300** ἐπώνυμον: *cf.* 733, 850, and n. 15.

**301** αὐτόκτιτ': *cf.* Hesiod, *Theog.* 813; but Rackham in *CR* **41**: 9, 1927, prefers "made by yourself."

ἄντρα: n. 133 f.

σιδηρομήτορα: *cf.* 242. Ocean is out of his element (Sikes and Willson).

**302** θεωρήσων: *cf.* 299 and θεωρός at 118. "Ringcomposition": van Otterloo, 86 ff.
τύχας: n. 272.

**303** συνασχαλῶν: 162, 288, 243. Enemies come to stare and jeer; friends, to sympathize and to witness Zeus' harshness.

**304** δέρκου θέαμα: 69, 119, 140.

Διὸς φίλον: formerly. Prometheus' answer to 296 f.: no friendship is necessarily firm and lasting, and friendship with a tyrant is especially insecure (225), for it cannot admit the frankness that is the hallmark of true friendship (611).

**305** συγκαταστήσαντα: 199–225. *Cf.* n. 295.

**304–306** *Cf.* 92–95, 141–143: Cammelli, who handles this scene carefully and completely.

**305** τυραννίδα: nn. 10 and 222.

**306** οἵαις: as in 93, 141, 268.

πημοναῖσι: n. 237.

κάμπτομαι: nn. 32, 237.

**307** ὀρῶ: as Cratos to Hephaestus (70). *Cf.* n. 299. Ocean witnesses as the Chorus did at 141: Cammelli.

παραινέσαι: Not welcomed by Prometheus (n. 264), although that is exactly what he did for the Titans (τὰ λῷστα, 308 and 204).

**308** ποικίλῳ: *cf.* 59, 62. Prometheus is in some respects like Odysseus: *cf.* δόλος (213).

**309** γίγνωσκε σαυτὸν: "endeavor to know thyself") (γνῶθι, denoting accomplishment. *Cf.* n. 72.

μεθάρμοσαι: Ocean advises a change of character, which would be impossible for the inflexible Prometheus. μεθάρμοσαι is Ocean's answer to κάμπτομαι (306) with all its implications.

τρόπους: i.e., his philanthropy (11 and 28).

**310** νέους: Ocean is a time-server and a courtier (Groeneboom, 146 and n. 151), who can adapt himself to any change of administration. On anadiplosis: n. 29. On *new*: n. 35. The doubling of νέος is the converse of the doubling of θεός:

Prometheus should act suitably to the new situation instead of being at odds with his fellow-gods.

τύραννος: n. 222.

**311** τραχεῖς: n. 80. *Cf.* 324: a tyrant may be τραχύς, if he chooses; a subject, such as Prometheus, should not adopt this character.

τεθηγμένους: Prometheus' words are like the wedge driven through his breast (64). Hate is like a sharp sword wielded by enemies against one another: *cf.* δίθηκτον . . . ξίφος (863), of the Danaids. Hypermestra, who allowed the edge of her hatred to grow dull (866 f.), exemplifies the only way that Zeus and Prometheus can ever be truly reconciled. Ocean's statement is profoundly true, though in his mouth it may be no more than an expression of his wordly wisdom.

**312** ῥίψεις: Words are Prometheus' only weapon (*cf.* 1043 and n. 180): Harry.

**313** θακῶν: *cf.* n. 201 on the implications of this throne.

τάχ' ἄν . . . κλύοι: Zeus, of course, is not omniscient: he sees what he looks at (54), and he hears if he happens to be listening.

**312–314** Fulfilled at 947 ff.; similar warning in 934.

**314** παρόντα: *cf.* n. 271.

μόχθων: of Prometheus, 99, 244, 314, 541, 756, 1026. Turned against Zeus at 913. *Cf.* n. 383 on Ocean. Never used of Io; because her sufferings were not of a violent enough nature (μόχθοι used of Heracles' labors)? Prometheus helped to relieve the μοχθήματα of men (464), and he must suffer μόχθοι in payment: n. 18.

παιδιάν: *cf.* n. 31.

**315** ταλαίπωρ': n. 231.

ὀργάς: n. 80.

**316** ζήτει: The Chorus gave similar advice in 262.

πημάτων ἀπαλλαγάς: Also at ends of 471, 754. *Cf.* 749 f. (Io). A descendant of Io will secure Prometheus' release (773).

**317** ἀρχαῖ': Ocean means that his advice may sound like a succession of outworn platitudes (e.g., 309). Is this veiled irony? Ocean uses old adages to preach the new order (309 f.).

**318** τοιαῦτα: refers to οἵαις in 306.

ἄγαν: n. 72.

ὑψηγόρου: n. 18, and of Typho at 360.

**319** γλώσσης: Speech reveals the mental state —Ocean finds Prometheus too haughty and vain (329); Cratos reveals his unfeeling harshness (78); and Io betrays her madness (884).

**320** ταπεινὸς: as the subjects of a tyrant should be. But at 908 Prometheus predicts the humbling of Zeus: ἴσα πρὸς ἴσα. He scornfully repudiates ταπεινότης at 1003–1006.

οὐδ' εἴκεις κακοῖς: *cf.* 178 f.

**321** πρὸς τοῖς παροῦσι δ'ἄλλα: n. 314.

**322** διδασκάκῳ: Ocean again tries to assume Prometheus' role, as at 293 f., 307 f.

**323** κέντρα: 597, 692; *cf.* μάστιξ (682), λακτίζω (651, 881)—all of cattle: Dawson, 238 f. and his n. 2. *Cf.* nn. 5 and 81 *sup.*

**324** τραχὺς: n. 311.

μόναρχος: Only here. The courtier's synonym for τύραννος, which Prometheus did not hesitate to use (305). *Cf.* the Chorus' estimate of Zeus in 184 f.

οὐδ' ὑπείθυνος: A technical term in Athenian democracy, as in *Persae* 213. *Cf.* n. 50.

κρατεῖ: n. 148.

**326** *Cf.* 262. Ocean regards himself as uncommonly persuasive, but cannot succeed with Prometheus.

**327** ἡσύχαζε: "lie low," which is the equivalent for Prometheus of "stop talking," since Prometheus can *do* nothing. But to the teacher, revealer and aggrieved victim of injustice it is utterly impossible to stop talking, and the advice offends Prometheus, *cf.* 344.

μηδ' ἄγαν: Ocean now uses the other famous ἀρχαῖον (317, n. 309). The adage also occurs at 72.

λαβροστόμει: *cf.* 180, 311, 318. Animal savagery: λάβρως of the eagle (1022). In a sense, the eagle λαβροστομεῖ Prometheus: the violence of the eagle's beak punishes the violence of Prometheus' words. Io describes herself (600) as λαβρόσυτος )(Prometheus' immobility. λαβροστομεῖν is a converse of χαριτογλωσσεῖν (294): Ocean is a smooth and persuasive fellow, while Prometheus is as fierce as a wild beast.

**328** οὐκ οἶσθα: nn. 186 and 322.

ἀκριβῶς: A further jibe at Prometheus' wisdom. The word does not recur; elsewhere Prometheus' knowledge and pronouncements are characterized

by σαφηνῶς, σαφῶς, σκεθρῶς, τορῶς, οὐκ αἰνικτηρίως (see Index), some of which adverbs certainly mark Prometheus as an oracle comparable to Delphic Apollo. It is ironic that Ocean should heap Delphic wisdom (309 and 327) on such a one.

περισσόφρων: *cf.* 62. Ocean, who began by claiming to be Prometheus' firmest friend, now adopts the point of view of Cratos and of Hermes in 944. *Cf.* n. 72.

**329** γλώσσῃ: n. 319.

ματαίᾳ: Prometheus' retort in 342.

ζημία: Retort in 382 f.

**330** *Cf.* 263–265.

αἰτίας: *cf.* 194, 226, 255.

**331** τετολμηκώς: At 299 Prometheus questioned Ocean's courage, a quality on which Prometheus prides himself (n. 235). At 381 Ocean accepts the heavy irony literally: so Grene in *CPh* **35**: 36 f., 1940. But Denniston in *CR* **47**: 164, 1933, denies irony and emends to πάντων μετασχεῖν (Weil) οὐ τετολμηκώς, while Thomson suggests (his n. 347) πάντων μετασχεῖν δὲ τετολμηκώς τ' ἐμοί. Groeneboom supposes a verse lost after 331. Cammelli, following Wilamowitz and Mazon, believes that Ocean did help Prometheus in some way of which we know nothing. Preferable to the latter hypothesis is that of Solmsen (129, n. 23) that Ocean could be regarded as a helper because he was a Titan and a brother of Cronus.

**332** ἔασον: is turned back at Prometheus in 384.

μελησάτω: Prometheus urges Ocean to feel the same indifference to him that he feels towards Zeus (938). Ocean might as well be an out and out member of Zeus' party, for he has been talking like Cratos (328).

**333** πείσεις: 34 and n. 172.

**334** πάπταινε: recurs in Hermes' mouth (1034). ἀμείνων is in both passages too: 335 and 1035.

πημανθῇς: Ocean may suffer πήματα such as Prometheus experiences (316).

**335** *Cf.* 322, 328, 473 ff.

φρενοῦν: As Prometheus did for men (444).

ἕφυς: Ocean delineates Prometheus' essential characteristic, as Hermes does his own at 969. *Cf.* n. 224.

**336** σαυτόν: 309 hovers in the background.

ἔργῳ κοὐ λόγῳ: 1080.

τεκμαίρομαι: Ocean uses another Promethean word (*cf.* διδασκάλῳ, 322): 454, 605.

**337** ὁρμώμενον: expresses Ocean's eagerness (προθυμίας 341, προθυμεῖσθαι 381) to serve Prometheus. Ironical echo in 393.

**338 f.** δωρειὰν . . . δώσειν: Prometheus, not Zeus, is the giver of gifts: n. 251.

**339** ἐκλῦσαι: n. 27.

**340** The whole verse is ironical, and the words οὐδαμῇ λήξω ποτέ express, though in a trivial context, Prometheus' inflexibility: n. 165.

**341** προθυμίας: n. 337.

**342** μηδὲν πόνει: πόνος three times in two verses. Don't play at being Prometheus, for πόνοι belong to Prometheus (n. 267).

μάτην: Ocean's pleas to Zeus would prove as futile as Prometheus' denunciations (329) and Ocean's smooth words (293): *cf.* 333. Prometheus here assumes the tone of Cratos at 44: *cf.* n. 299. In 1001 Prometheus adopts the same tone to Hermes. οὐδὲν ὠφελῶν: It is useless for Ocean to try to adopt the role of Prometheus (n. **222**).

**343** θέλεις: echoes 321.

**344** ἠσύχαζε: Prometheus' angry retort to 327.

σαυτὸν: echoes 336 and 309. In fact, ἠσύχαζε σαυτὸν has the form of γίγνωσκε σαυτόν, although the syntax of σαυτόν is different.

ἐκποδὼν: *cf.* 263.

**345 f.** Prometheus is as compassionate towards Ocean as he was to man. His tone relaxes its bitter irony as he prepares to tell of his brothers, Atlas and Typho. Or does he ironically assume Ocean's altruistic tone?

**345** δυστυχῶ: So Chorus in 508. *Cf.* n. 272.

**346** θέλοιμ': θέλω sheds its irony (321, 343) and expresses Prometheus' nobility of character, as we see it again in 443–450 and in 239.

πημονὰς: picks up πημανθῇς (334).

**347** τύχαι, τυχεῖν (346), δυστυχῶ (345): n. 272.

**350** ἄχθος: *cf.* the burden of Prometheus' suffering in 26.

οὐκ εὐάγκαλον: Atlas' fate is the converse of Prometheus' (1019).

**351** γηγενῆ: 567, 677.

**352** ἰδὼν: In the sympathetic spirit in which the Chorus look at Prometheus.

ὤκτιρα: The compassion of Prometheus forms the bridge between the end of his first dialogue with Ocean (345 f.) and his monologue.

δάιον τέρας: Typho, the violent, was violently overthrown by Zeus, who one day may have to face a more serious encounter (921).

**353** πρὸς βίαν: n. 74.

**354** Typho resisted all the gods, as Prometheus did: n. 29 and 975. Headlam's emendation, θεὸς . . . θεοῖς, strengthens the parallel.

**355** σμερδναῖσι γαμφηλαῖσι = ἀγρίαις γνάθοις (368), but heightened. Typho was more terrible when free, but retains his essential character in captivity.

συρίζων: Typho had snake heads, *cf.* Hesiod's description in *Theog.* 820 ff.

**356** *Cf.* n. 53.

γοργωπὸν: Io encounters the Gorgons in 799. As will be noted later, most of Io's adventures have points of contact elsewhere in the play: the lengthy tale of her wanderings is not solely a geographical digression.

**357** τυραννίδ': n. 222.

ἐκπέρσων: *cf.* 956.

βίᾳ: n. 74.

**358** ἄγρυπνον: refers to Zeus, who was ever watchful (Sikes and Willson). The word also describes Argus, and is applied to Prometheus at 32.

βέλος: Typho strikes back (371) in the only way he can: *cf.* Prometheus, reduced to words. Zeus, however, has been struck by the arrow of love (649): and if he should be similarly smitten of Thetis, his thunderbolt (917) would thereby lose its power.

**359** ἐκπνέων φλόγα: *cf.* Typho himself in 371.

**360** ἐξέπληξε: Here the word is used in a natural way: *cf.* n. 134.

ὑψηγόρων: *cf.* Prometheus in 318. Thomson notes that Prometheus fails to see the application to himself.

**361** κομπασμάτων: Of Prometheus at 947, of Zeus at 1031.

**362** σθένος: n. 55.

**363** ἀχρεῖον: Typho's efforts and labor came to nothing—*cf.* the theme of wasted labor in Prometheus' dialogue with Ocean, n. 342.

δέμας: Four times of bodies tortured and confined (living, but reduced to the status of a structure): 146, 1018, 1051.

**365** Typho beneath Etna, Atlas under the western mountains (348–350), Prometheus atop the Caucasus, the three brothers are well separated. Typho and Atlas are hidden from jeering observers: *cf.* 151 ff.

**366** μυδροκτυπεῖ: So Hephaestus hammers on Prometheus in the Prologue. On κτύπος, n. 133.

**367–369** An instance of Prometheus' prophetic powers: *cf.* 101 ff., 209 ff., 848 ff.

**368** ποταμοὶ: Another destructive river in 717. δάπτοντες: Typho wreaks his destructive anger on others; Prometheus (437), to a certain extent, on himself.

ἀγρίαις γνάθοις: n. 355.

**369** λευρὸν: Used also of the path of aether (394), over which Ocean is free to move and in which Prometheus is confined. )(the rocks, which are ὀκριόεις (281, *cf.* 1016), etc. Sicily is the antithesis of Scythia: καλλικάρπου)(ἀνηρότους 708. Editors identify the description with the great eruption of Etna in 479/8 B.C., thus getting a *terminus post quem* for the play.

**370** χόλον: Of gods in general (29), Titans (n. 199), Zeus (376). The eagle probably attacks Prometheus' liver (1025) because of his ὀργή (378 and n. 80).

**371** ἁπλάτου: dangerous to approach, n. 125.

βέλεσι: n. 358.

πυρπνόου: n. 359. The collocations βέλος . . . ἐκπνέων (358 f.) and βέλεσι πυρπνόου make the parallel conspicuous.

**372** κεραυνῷ: Zeus' principal weapon, used against Typho (359–362, 372), Inachus (668), and Prometheus (1017), is not invincible (922) in Prometheus' opinion.

ἠνθρακωμένος: 362.

**373** διδασκάλου: Prometheus was angered by Ocean's claim in 322, *cf.* n. 193.

**374** σεαυτὸν σῷζ': n. 344. Prometheus' retort to 309.

ὅπως ἐπίστασαι: Ocean is a coward, n. 331. ἐπίσταμαι is a Promethean word, like διδάσκαλος

and τεκμαίρω (n. 336), suitable in the mouth of a teacher. Ocean's knowledge is not of the future or of useful arts, but the knowledge of a courtier —how to keep out of trouble through all changes of administration (307–310): *cf.* 265, 840, 967. Hermes attributes wisdom to Zeus (980, 1032) and denies it to Prometheus (982).

**375** παροῦσαν: n. 271.

ἀντλήσω: Prometheus is prepared to drink his cup of suffering unaided by mortals (84) or Ocean.

τύχην: n. 272.

**376** *Cf.* 175–177, 190–192.

λωφήσῃ: n. 27.

χόλου: n. 370.

**377 f.** Ocean comes back to his offer of 338. Ostensibly the adage refers to Zeus' wrath (*cf.* n. 592), but it is equally applicable to Prometheus'.

γιγνώσκεις: Ocean again tries to teach Prometheus: *cf.* 293, 307 ff., 322, 335 f., 373.

ὀργῆς: n. 80.

νοσούσης: n. 225.

ἰατροὶ: Prometheus himself was a physician to men: 478 ff., *cf.* 473 f.

**379 f.** καιρῷ: n. 507.

μαλθάσσῃ: The Scholia quote Hippoc.: πέπονα φαρμακεύειν, μὴ ὠμά. *Cf.* n. 79: softness would seem to be equally impossible for Zeus and Prometheus. μαλθάσσω, σφριγάω and ἰσχναίνω are all medical terms, and Ocean's metaphor is from the reduction of a swollen joint by soothing applications—Thomson; Dumortier, *Images*, 30 f.

κέαρ: n. 166. Prometheus too had believed (186 ff.) that Zeus' heart could be softened.

βίᾳ: n. 74. The wrong approach in medicine as in politics (208, 212 f.). *Cf.* 1008 and 1010 (μαλθάσσῃ . . . βιάζῃ): when μαλακοὶ λόγοι fail, Hermes tries βία and fails equally.

**381** προθυμεῖσθαι: n. 337.

τολμᾶν: Ocean was stung by 374: *cf.* n. 331.

**382** ζημίαν: *cf.* 329. Ocean is surprised at the self-confidence of Prometheus, who is clearly (to Ocean) the guilty one.

δίδασκε: Ironical, *cf.* 373. "Show me, if you can." In the play many sincere questions are addressed to Prometheus by the Chorus and Io (the oracular power of Prometheus accounts for the extraordinary number of interrogative sentences), and many sincere appeals for information are directed to him: 193, 606 f., 618, 625, 631, 634, 698, 763, 765, 779, 782 f., 821 f., 950.

**383** Groeneboom notes that this biting retort is confined to one verse.

μόχθον: n. 208.

περισσὸν: Wasted labor, as in 363, 342 f. Prometheus' retort to περισσόφρων (328). Ocean regards Prometheus as too wise for his own good, while Prometheus considers Ocean a meddling busybody.

κουφόνουν . . . εὐηθίαν: Tempting challenge to a teacher (443 f.).

**384** ἔα: 332, 978.

νόσῳ νοσεῖν: n. 378.

**385** It is better to be wise and considered foolish than to have the reputation for wisdom (περισσόφρων) and be foolish: *cf.* 335 f.

**386** δοκήσει: picks up δοκεῖν, as often in angry retorts: e.g., 69 f.

ἁμπλάκημ': A new interpretation of Prometheus' sin: it was folly, not theft (112). *Cf.* the theme of ἀβουλία, introduced at 18 and exploited by Hermes (1012–1035). Cammelli sees in this verse a covert warning to Zeus, since Prometheus is looking to his future liberation, *cf.* 389.

**387** σαφῶς: As Prometheus usually expresses himself, nn. 227 and 328.

στέλλει: Ocean is right (392).

**388** θρῆνος: Ocean's lamentations would be useless (43), and might even anger Zeus (*cf.* 313).

ἔχθραν: Prometheus' own state—37, 120, 158, 864, 973, 975, 978, 1042 bis. Prometheus' intentions are kind (345 f.), although he is offensively blunt.

**389** renews 201 ff. On παγκρατεῖς: n. 149.

**390** φυλάσσου: *cf.* 373 f. Prometheus warns Io in 715 and 804. Now he is teaching Ocean (382, 391), who proves a quick pupil.

ἀχθεσθῇ: n. 370.

κέαρ: n. 379.

**391** συμφορὰ: *cf.* 974. Of Zeus at 758.

διδάσκαλος: Ocean accepts Prometheus as a teacher, *cf.* nn. 322, 373, 382. Prometheus' fate is more instructive than his words, as Prometheus implied in 373 f.

**392** Similar angry sequence of imperatives at 937. Spoken in a loud voice (393).

στέλλου: 387.

σῷζε: renews 374—Ocean will thereby save himself.

νοῦν: good sense )(383.

**393** ὁρμωμένῳ: As eagerly as at 337, but in a different direction (so Reinhardt, 46). Ocean shows the same volatility as his daughters (n. 133); but whereas he suddenly decides to abandon Prometheus, they unexpectedly resolve to stay by him (1063 ff.). Motility of water?

ἐθώυξας: n. 277.

**394** λευρὸν . . . οἶμον: )(Scythia and the Caucasus, 2 and n. 369. Ocean's life is untouched by suffering.

**395** τετρασκελὴς: seems to eliminate Thomson's flying fish, n. 286.

**395 f.** ἄσμενος . . . κάμψειεν γόνυ: nn. 23 and 32. Ocean consults the whims of his steed; Nature may accidentally please Prometheus, who is reduced to the status of a domestic animal that is cruelly treated.

FIRST STASIMON: 397–435

**397** στένω: The key-word of the ode (Thomson, Groeneboom). Van Otterloo, 50, traces the series: 397, 406, 409, 413, 430, 432, 433, 435.

**398** τύχας: n. 272.

**399–401** Emended by Platnauer in *Humanitas* (Coimbra) **4**: 71–75, 1952.

**399** δακρυσίστακτον: 144 ff.

ὄσσων: The seat of sympathy, n. 144 )(356.

**401** παγαῖς: n. 89.

**403** *Cf.* 150, 187 f., 324. Prometheus dared to maintain his ἰδία γνώμη against Zeus (543). 403–408 sim. 148–151.

**404** ὑπερήφανον: *cf.* ὑψήγορος (318, 360). Zeus is as high-handed as Prometheus.

θεοῖς τοῖς πάρος: *cf.* 151.

**405** αἰχμάν: 925.

**408** μεγαλοσχήμονα: *cf.* πελώρια (151).

ἀρχαιοπρεπῆ: )(νέοι θεοί.

**410** τιμάν: suggests the theft of τιμαί (n. 30), which produced their fall, and the probable restoration of Prometheus' lost τιμαί at the end of the trilogy.

**414** θνατοί: who cannot, however, help him.

**416** μάχας ἄτρεστοι: The Amazons (723 ff.), whom Io will encounter. The Danaids are similar.

**417 f.** *Cf.* 1 f.

**421** ὑψίκρημνον: *cf.* 5.

**423** δάιος: Of Typho in 352.

**424** ὀξυπρῴροισι: Metaphor from boats preparing for the ἐμβολή: Groeneboom. *Cf.* gadfly (674), griffins (803), and Prometheus' eagle, all of which are armed to war on Prometheus and Io.

**425** Why had they not seen Typho? Sicily far from Ocean?

**425–430** much emended. See Longman in *CR* N.S. **2**: 1 f., 1952.

**426** δαμέντ': of Prometheus 165, 601. *Cf.* n. 6: Zeus is destined to be overthrown, as were the Aegyptiads (861).

ἀδαμαντοδέτοις . . . λύμαις: *cf.* 148.

**427** εἰσιδόμαν: n. 146.

**428** ὑπέροχον: *cf.* ὑπερήφανον: of Zeus (404). Zeus and his opponents were all titanic.

σθένος: n. 55.

**430** ὑποστενάζει: *cf.* n. 397. Hermann's emendation, ὑποστεγάζει, is more literal and prosaic; on the other hand, all the occurrences of στεν- in the ode might cause the alteration of στεγ-.

**431** πόντιος: Prometheus calls on the sea for sympathy in 89.

**432** ξυμπίτνων: in sympathy. Compounds of συν- denoting sympathetic feeling or helpful action are common in the play: συγκαθίστημι 305; συγκάμνω 414, 1059; σύμμαχος 221; συμπαραστατέω 218; συμπονέω 274; συμπράσσω 295; συναίρω 650; συναλγέω 288; συνασχαλάω or -ασχάλλω 243, 303; συνθάλπω 685.

**433** Ἅιδος . . . μυχὸς: Where Prometheus would have liked to be confined, n. 152.

**434** παγαί: *cf.* 89, 401, 431.

**435** ἄλγος: 197 f., 261, 699.
οἰκτρόν: rounds out the theme of the ode, n. 397.

SECOND EPISODE: 436–525

**436** χλιδῇ: is ironical, as in 972 f.—the wantonness of the rich, luxuriating in their soft life (466). αἰθαδίᾳ: 50, 324. *Cf.* Prometheus' treatment of Ocean in the preceding scene (Wilamowitz, 120,

122) and of Hermes later. The wedge (64) is a manifestation of Zeus' αἰθαδία (*cf.* 907, opp. ταπεινός); used of Cratos in 79 (opp. μαλακία); of Prometheus in 964, 1012, 1034, 1037 (opp. εὐβουλία).

**437** σιγᾶν: Prometheus must have remained silent for a time after 435, as during 1–88 and perhaps after 587. *Cf.* 106 f., 197 f. When he is silent he is pondering his situation, as the following words show. On Aeschylean silences in general, *cf.* Groeneboom.

δάπτομαι: *cf.* n. 368 and the eagle's attack.

**438** προυσελούμενον: n. 93.

**439 f.** Superficially inconsistent with 299. P. Roussel in *Rev. de phil.* **44**: 244–247, 1920, sees an allusion to Hes., *Theog.* 535 ff. One result of Prometheus' σύνοια is the realization that Zeus would have had no γέρα to distribute if Prometheus had not helped him to power: so Schol. and M. Wecklein. Prometheus has been pondering Zeus' ingratitude: *cf.* 239–241, 304–306.

νέοις: n. 35.

γέρα n. 38, and *cf.* τιμή, which is very close in meaning.

διώρισεν: corresponds to διεστοιχίζετο (230). Prometheus' uniqueness, cf. 234.

**441 f.** *Cf.* 373 f., 827.

**442** πήματα: identifies Prometheus with men (Havelock, 56).

**443 f.** Prometheus as wise man and teacher.

**444** φρενῶν: is picked up in 472. By giving men wisdom Prometheus made them like himself.

**446** δέδωκ': n. 251.

εὔνοιαν: *cf.* 11, 28, and )(tyrants, who think only of their own welfare.

ἐξηγούμενος: n. 214.

**447 f.** Wasted labor, as in 342 f., 383. *Cf.* Matthew 13: 13.

**449** μακρὸν βίον: The life of primitive man was tedious, as Prometheus' aeons of suffering will be )(537: a long life can be pleasant, if nourished by hope. Prometheus gave man hope (250).

**451 ff.** προσείλους . . . ἀνηλίοις: like Hades (433) and the Chorus' dwelling (133 f.).

**454** τέκμαρ: n. 336.

**456** ἄτερ γνώμης: )(the wise Prometheus. *Cf.* n. 287.

**458** δυσκρίτους: Prometheus was an oracle to men (486, 662).

**459** σοφισμάτων: Picked up in 470 ironically, just as φρενῶν (444) in 472. *Cf.* n. 62.

**460** ἐξηῦρον: n. 59.

**461** ἐργάνην: leads over to the domestication of animals: Nestle, 20.

**462** ἔζευξα . . . ἐν ζυγοῖσι: Prometheus and Io are yoked like animals, nn. 71 and 81.

κνώδαλα: *sc.*, before they were tamed. Typho too was tamed: 355, 368. In writing κνώδαλα and 466 could Aeschylus have been influenced by *Odyssey* 17.310 and 317?

**463** δουλείοντα: The status of domestic animals and of the victims of tyrants, opp. ἄρχειν (n. 927).

**464** διάδοχοι μοχθημάτων: *cf.* 1027. Zeus may be ungrateful for Prometheus' services, and man may be helpless to aid, but Chiron will be for Prometheus what Prometheus was for man: *cf.* n. 1026–1029.

**465** φιλησίους: Animals are suited to subjection, Prometheus is not (1009 f.).

**466** χλιδῆς: n. 436.

**468** ῥῦρε: n. 460 and 469.

**469** μηχανήματ': *cf.* n. 59. At 989 Zeus fails to find a μηχάνημα.

**469–471** *Cf.* 239–241 and 473–475. Prometheus speaks of himself as a clever man who could discover no device to help himself, and the Chorus compare him to a physician who can find no remedy for his own disease. The four-line "buffer" of the Chorus (472–475) thus has the form of the end of Prometheus' first speech, while at the same time it introduces the subject of his second.

σόφισμ': n. 459.

παρούσης: n. 271.

πημονῆς: n. 442. Prometheus relieved the πήματα of men, but cannot relieve his own.

ἀπαλλαγῶ: n. 316.

**472** αἰκὲς: The Chorus accept Prometheus' own estimate, 438 and n. 93.

πῆμ': picks up πημονῆς.

φρενῶν: Prometheus, who made man intelligent (n. 444), wanders in his own wits. At 842 he vindicates the soundness of his φρένες. He never raves as Io does, but his despair and denuncia-

tions of Zeus seem to the Chorus to verge on madness.

**473** πλανᾷ: Literally true of Io (565, 572), but Prometheus is immobilized: *cf.* the irony of ἐλαφραῖς (125), κίνυγμα (158), ἐλαφρόν (263), ἐλαφροί (278).

ἰατρὸς: n. 378. Physician, heal thyself: Mark 15: 31. The simile goes from ἰατρὸς to ἰάσιμος in 475. On the image of the physician see Mielke, 21 f.

νόσον: n. 378.

**474** ἀθυμεῖς: His disease is ἀθυμία.

σεαυτὸν: *cf.* n. 374. The word reminds us how full their father was of advice to Prometheus for self-improvement.

**475** εὑρεῖν: picks up ηὗρε (468) and ἐξευρὼν (469), and emphasizes the fact that the Chorus' simile is a variation on Prometheus' closing statement. *Cf.* n. 59.

φαρμάκοις: )(Prometheus' successes in 249 and 480. At 606 Io asks for a φάρμακον, which she receives.

ἰάσιμος: n. 473.

**477** τέχνας: binds the speech together (Thomson's n. 492): *cf.* 497, 506, and nn. 7, 87, 110.

πόρους: 111. At 59 Cratos expressed the fear that Prometheus could find a πόρος for himself out of his difficulties, a fear as yet unjustified (469–475).

ἐμησάμην: makes him πολύμητις, like Odysseus, *cf.* 206, 213, and his many sufferings.

**478** ἐς νόσον πέσοι: Prometheus takes his cue from 473 f. He is still proud of his services to men (τὸ . . . μέγιστον) despite the apparent incurability of his own ills.

**479** οὐκ ἦν ἀλέξημ': *cf.* ἄκος . . . οὐδέν (43). θρηνεῖσθαι is no remedy, and Prometheus himself gives it up (615).

**480** φαρμάκων: renews φαρμάκοις (475).

**482** ἔδειξα: n. 170.

ἡπίων: an epithet of φάρμακα in Homer (Bergson, 86). Otherwise, one might suppose that the word was intended to show Prometheus' εὔνοια (446).

ἀκεσμάτων: *cf.* n. 479.

**483** νόσους: n. 378.

**483 ff.** The transition from medicine to soothsaying was easy because of the ἰατρομάντις (e.g., Empedocles), who was concerned with both: Nestle, 20, and Groeneboom.

**484** μαντικῆς: Io visits Dodona (831) and her life was changed by Delphi (658, 669). Prometheus himself functions as a soothsayer to her.

ἐστοίχισα: Human improvement was the realm of Prometheus (*cf.* 230). Prometheus set in order that part of Zeus' realm that Zeus himself neglected: n. 231.

**485** ὀνειράτων: *cf.* Io's dreams (645 ff.), which proved ὕπαρ.

**486** δυσκρίτους: n. 458.

**487** ἐγνώρισ': Prometheus the teacher: 110, (322), 373, 391; (10), 196, 382, 634.

**488** γαμψωνύχων . . . οἰωνῶν: of which the eagle is one.

σκεθρῶς: Prometheus brought man to his own level (102): n. 444.

**489** διώρισ': As in 440 for the gods. In these two passages Prometheus speaks of himself as a Zeus, setting in order the affairs of both gods and men.

**490** δίαιταν: "habitat"—Rackham in *CR* **41**: 9, 1927.

**492** All the nouns are elsewhere applied to Prometheus' relations with Zeus: ἔχθραι to their present enmity (n. 388); στέργηθρα to the possibility of a future reconciliation (11, and Prometheus' own interpretation at 191 f.); and συνεδρίαι which can mean "sitting in council together," to their past cooperation (216–221, where βουλαῖς alludes to their deliberations).

**494** δαίμοσιν πρὸς ἡδονήν: *cf.* 660. The gods are capricious, and men can hardly know how to please them without soothsayers.

**495** εὐμορφίαν: The εὐμορφία of Prometheus' liver will be damaged (1025).

**497** δυστέκμαρτον: n. 336.
τέχνην: n. 477.

**498** ὤδωσα: As he does literally for Io at 707–735, 790–815; NB. 706, 813.

φλογωπὰ: 253, 791.

σήματα: n. 295.

**499** ἐξωμμάτωσα . . . ἐπάργεμα: *cf.* the condition of men in 447.

**500 f.** *ἔνερθε δὲ χθονὸς κεκρυμμέν'*: n. 365.

*κεκρυμμέν'*: Prometheus is the revealer of hidden things, n. 193. The transition from soothsaying to metallurgy is made by the association of *ἐπάργεμα . . . κεκρυμμένα*: Nestle, 20 f.

*ὠφελήματα*: n. 33.

**502** *σίδηρον*: is used on himself.

**502 f.** *Cf.* nn. 29, 234.

**503** *ἐξευρεῖν*: n. 59.

**504** *σάφ' οἶδα*: n. 227.

*μάτην φλῦσαι*: As he feels that Ocean did (329, 342 f.).

*θέλων* too is an echo of the scene with Ocean (n. 346).

**505** Typical bluntness: *cf.* nn. 46 and 641.

*μάθε*: n. 273. *Cf.* 553, 586, 609, 624 bis, 701, 760 (codd.: *γαθεῖν* Murray), 926. Most of the learning comes in the scene with Io.

**506** A proud and self-confident declaration )(the mood of 115–127. Prometheus is at his best before a sympathetic audience. *Cf.* nn. 7, 110 and 477.

**507** *βροτοὺς*: picks up *βροτοῖσιν*.

*ὠφέλει*: *cf.* 501.

*καιροῦ πέρα*: )(*ἐν καιρῷ*, 379. *Cf.* nn. 247 and 72.

**508** *σαυτοῦ*: n. 474.

*ἀκήδει*: )(Zeus, who was indifferent to men (231 f.).

*δυστυχοῦντος*: n. 345.

**509** *εὐελπις*: n. 250. The circumstances of the Oceanids' life make hope easier for them than for Prometheus.

**510** *λυθέντα*: n. 27. First of a chain of passages on release: 770 f., 785, 873, 1006.

*ἰσχύσειν*: of tyrants. Prometheus found *δόλος* preferable to *ἰσχύς* (212). The Chorus dare to hope that Prometheus will one day no longer be in the power of Zeus (*cf.* n. 148 on *κρατέω*), though he now has less power. Prometheus seizes upon the latter phrase in his reply.

**511** *τελεσφόρος*: Prometheus' woes have a *τέρμα* (n. 100).

**512** *κρᾶναι*: n. 211.

*πέπρωται*: is used of the fates of Zeus (518 f.), Prometheus (103) and Io (815), which are fixed, but not necessarily known.

*μυρίαις*: n. 94.

*πημοναῖς*: n. 237.

**513** *δύαις . . . δεσμὰ φυγγάνω*: *cf.* 525, and n. 179.

*καμφθείς*: n. 163.

**514** Prometheus' answer to 508 (Groeneboom). *Cf.* n. 477.

*ἀνάγκης*: n. 16.

**515** *οἰακοστρόφος*: The Chorus had supposed it was Zeus (149).

**516** *Ἐρινύες*: Zeus' justice is like that of the Erinyes in the *Choë.*: Maddalena, 143. Vandvik, 34, considers this one of Prometheus' delusions.

**517** *ἀσθενέστερος*: *cf.* 514. Zeus is as truly in the grip of *ἀνάγκη* as Prometheus. Typho (362) and Atlas (428) have been deprived of their *σθένος*: *cf.* n. 55.

**518** *ἐκφύγοι*: 513, 525. Prometheus alludes to the affair with Thetis (Schol.). Zeus can no more escape his fate than Prometheus, his bonds. A new view of Zeus )(50: Pohlenz. In fact, however, we know that Prometheus was released and that Zeus did not fall.

**519** *πέπρωται*: 512, 518.

*κρατεῖν*: The converse of *ἀσθενέστερος* (514, 517) and *μεῖον ἰσχύσειν* (510).

**520** *πίθοιο*: Prometheus as a source of knowledge—617, 744, 963, 988, and *cf.* n. 505.

*λιπάρει*: A womanly characteristic in the eyes of Prometheus: 1004. He has an annoying way of withholding information: 621)(617, 624, 766, 776, 963, 984 f.

**521** *ξυναμπέχεις*: Prometheus hugs his secret.

**523** *καιρὸς*: n. 507. Prometheus finds that the Chorus have violated *ὁ καιρός*. Their counsel in 507 annoyed him faintly because it was directed against that on which he most prides himself (506).

*γεγωνεῖν*: n. 193.

*συγκαλυπτέος*: At first sight an odd word in the mouth of the revealer, *cf.* n. 520 and n. 193. But Prometheus is concerned not only with the truth

to be revealed but also with the right circumstances for his revelations, the καιρός: *cf.* n. 20. Hence, the suppressions listed in n. 520. Zeus has not yet had his affair with Io (which does not exist for the audience, since they have not heard of it), from which will come Heracles, who will help to secure Prometheus' release (771–774); nor with Thetis, whose son will be mightier than his father (764–768). Zeus might yet be warned by a premature revelation (*cf.* 313). Once his unions with these women have taken place, he will have initiated an unbreakable chain of consequences. By hugging his secret a little longer Prometheus will escape.

**524** σῴζων: i.e., by keeping this secret safe, I save myself: a far different method of salvation from Ocean's contemplated pleas (n. 374).

**525** *Cf.* 513.

ἀεικεῖς: n. 93.

SECOND STASIMON: 526–560

**526** ὁ πάντα νέμων: *cf.* 229. The Chorus never question the supremacy of Zeus.

**527** γνώμᾳ: of Chorus )(γνῶμαι of Prometheus at 543 and n. 436, which are self-willed (n. 403). The Chorus wish not to oppose Zeus in order to avoid Prometheus' hybris (1002 f.) and his fate. The proper use of γνώμη is illustrated by Hypermestra (867) and in the third stasimon (*cf.* γνῶμαι at 888, similar position in ode).

**528** κράτος ἀντίπαλον: May mighty Zeus never wrestle against me (*cf.* the amatory wrestling of Zeus and Io, whose woes are described partly in athletic metaphors; and that referred to by the Chorus in 904). The Chorus do not refer specifically to marriage until the end of this ode, 555 ff. They believe Zeus invincible; but *cf.* 920–923, where Zeus' κράτος, symbolized by the thunderbolt, will find its match.

**529** ἐλινύσαιμι: n. 36.

**532** ἄσβεστον: n. 299.

**533** ἀλίτοιμι λόγοις: *cf.* 178–180, 311–324.

**535** ἐκτακείη: *cf.* 789.

**536** ἠδύ: Not ἀγαθόν, ἀληθές, or συμφέρον.

**537** *Cf.* n. 449 and Bacon in *CR* **42**: 117, 1928.

**539** εὐφροσύναις: The joy is but a fantasy (*cf.* n. 314), and reality returns in φρίσσω.

**540** *Cf.* 144 ff., 397 ff.

δερκομένα: 54, 93, 140, 304, 547, 679, 843.

**541** μυρίοις: renews 512.

διακναιόμενον: as in 94.

**542** τρομέων: n. 41.

**543** ἰδίᾳ: nn. 403 and 436. ἴδιος in the two passages brings out the αὐθάδεια of both Prometheus and Zeus.

γνώμᾳ: n. 527.

σέβῃ θνατοὺς: A paradox. At 937 Prometheus advises the Chorus to go on reverencing Zeus. *Cf.* 29 f.

**544** ἄγαν: n. 72.

**545** ἄχαρις χάρις: (codex Tric.): Similar oxymora in 904. Men are powerless to do favors for Prometheus; tyrants do none (985).

χάρις opp. κότος: Nestle, 31 f., 34. Prometheus did favors for men, Io, Ocean and the Chorus (782, 821), all of whom are powerless to requite him but grateful; and for Zeus, who is powerful but ungrateful. In his second edition, Murray accepts Headlam's χάρις ἀ χάρις.

**546** φίλος: See Index, *s.v.* φίλος and φιλότης.

**547** τίς ἐφαμερίων ἄρηξις: Ambiguous. Is there any help from mortals, or for mortals? With the first sense )(n. 267, and *cf.* Bacon, *loc. cit.* (n. 537 *sup.*). The second sense prepares for Io's entrance: Grene in *CPh* **35**: 38, 1940.

**548** ὀλιγοδρανίαν: )(πολυπραγμοσύνη, n. 18, and nn. 383 and 393 on Ocean. Only Zeus is truly free to act (939). *Cf. Odyssey* 9.515 f. and Ar., *Birds* 686 f.

**549** ἰσόνειρον: and ἀλαὸν (550) recall 447–449: Bacon, *loc. cit.*

**550** ἐμπεποδισμένον: shackled, like Prometheus (74).

**552** βουλαί: Of course, Prometheus is not θνατός, but the Chorus refer to him as much as to men: *cf.* antistrophe β' and verse 219, where we learn how Zeus rose to power through Prometheus' βουλαί. It is quite true that in this play Prometheus' βουλαί are no threat to Zeus' ἁρμονία: *cf.* 761 f.

**553** ἔμαθον: n. 505. Not all Prometheus' teaching is verbal and conscious: *cf.* 373 f., 391.

προσιδοῦσ': *cf.* 144 ff.

**554** τύχας: n. 272.

**555** προσέπτα: *cf.* n. 115.

**557** λέχος: The final verses of the ode prepare for the entrance of Io, and also look (Thomson) to the union of Zeus with Thetis. λέχος of Zeus and Io, 651: Zeus and Chorus, 895. The marriage of Prometheus and Hesione is in conscious contrast to the union of Zeus and Io: joyous, and properly conducted. On the joy, *cf.* 536 ff. and n. 31: Prometheus was not destined to lead a life of hope and joy for long.

ὑμεναίουν: )(Io's marriage, 663 ff.

**558** γάμων: n. 764 on the marriages of the play.

**560** πιθὼν δάμαρτα: Io became the δάμαρ of Zeus without persuasion (n. 172), and Prometheus expects one of her descendants to aid him in overcoming Zeus (n. 6).

THIRD EPISODE: 561–886

**561** λεύσσειν: 144.

**562** χαλινοῖς: *cf.* n. 81 on animal imagery. Ironic in comparison with 462 f. At 672 Zeus bridles Inachus.

χειμαζόμενον: Of Io in 838. *Cf.* n. 15.

**564** *Cf.* 193–195.

ἀμπλακίας: Question repeated at 620. *Cf.* n. 112.

σήμηνον: n. 295.

**565** μογερὰ: 594. Compared to Prometheus, Io is sorry for herself.

πεπλάνημαι: Key-word of Io's whole scene. *Cf.* n. 275 and 473. Pohlenz (I, 66) contrasts Prometheus' fixed position. πλαν- used of woe (275), once of Prometheus (473), but ten times of Io.

**566** χρίει: Only of the gadfly (597, 675, 880).

αὖ: Compresses a long tale of sorrow into two letters.

τάλαιναν: is used by Prometheus of himself at 108, 157, and 469 (*cf.* ταλαιπώρων at 231 of men); by Io of herself also at 571; and by Io of Prometheus at 594. The lots of Io and Prometheus are similar.

οἶστρος: also 879, to end her scene. *Cf.* 580, 589, 681, 836.

**567** γηγενοῦς: *cf.* n. 677.

**568** μυριωπὸν: Io is as much stared at as Prometheus. Scholia on 503 and 571 call Argus πανόπτης, making him the equivalent of the sun (91).

εἰσορῶσα: If φοβοῦμαι, which Dindorf and Wilamowitz deleted, were retained, this passage would closely parallel ὄρίσσω . . . δερκομένα in 540.

**569** δόλιον: Io fears Argus, but not Prometheus (213), of whose δόλος she knows nothing.

ὄμμ': n. 53.

**570** Earth will hide living Prometheus at 1018. In fact, the two situations are converse: Argus is dead but not hidden, while Prometheus will be hidden but not dead.

**571** τάλαιναν: n. 566.

**572** κυναγεῖ: *cf.* griffins (803), and Prometheus' eagle (1022); as well as θωύσσω (n. 277).

πλανᾷ: n. 565.

**573** νῆστιν: 599.

παραλίαν ψάμμον: Io is raving and imagines herself where Argus first afflicted her. This is not the only hallucination she has: *cf.* the εἴδωλον of Argus in 567. Wilamowitz (118) conceives Prometheus' rock as towering above the ocean, so that the sand would be literally present, citing as evidence 583; but there Io is calling upon Zeus to slay her by means of representative powers of nature (*cf.* 88–92).

**574** δόναξ: is a synonym of σῦριγξ (Schol.): 126, 355.

**575** ἀχέτας: n. 115.

ὑπνοδόταν: Ironic when applied to the buzzing of the gadfly, which afflicts Io without ceasing: *cf.* n. 358. Maddalena (145) sees here a reference to the pipe that put Argus to sleep.

**576** ἰὼ ἰώ: A pun on her own name, n. 15. *Cf.* Ajax's pun on his own name in Sophocles.

τηλέπλαγκτοι πλάναι: n. 565.

**578** ἐνέζευξας: n. 108.

εὐρὼν: n. 59.

ἁμαρτοῦσαν: *cf.* 259 f., 266. Both Prometheus and Io admit that they missed the mark; but Prometheus erred voluntarily with a definite objective in view, while Io knows that she must have erred only because she is punished. She is passive in her suffering, while Prometheus is rebellious, and in the end (976, 1093) feels that his punishment was unjust )(30. Io is a weak woman; Prometheus grows to exult in his sin.

πημοναῖσιν: n. 237.

**580** οἰστρηλάτῳ: For the type of compound, *cf.* 148. The sense is illustrated by 681 f.

δείματι: Even Prometheus is afraid at 127 and 1090, *cf.* n. 41.

**581** παράκοπον: When Io can say this, her frenzy is abating. *Cf.* 1056: Hermes calls Prometheus mad, though he is not; though Io recognizes that she is mad, Prometheus alludes to her insanity only once (848), and then as politely as possible.

**582 ff.** *Cf.* 152 ff. Io longs for death; Prometheus, for concealment, *cf.* 1018. Io's list of the powers of nature is less elaborate than Prometheus' at 88 ff.

**583** δάκεσι: *Cf.* Andromeda. The gadfly and the eagle bite but do not kill.

δὸς: n. 251. Zeus' gifts are as destructive as his discoveries (n. 59).

**584** εὐγμάτων: Prometheus' prayer (1043–1052, 1057) is answered because it suits Zeus' intention; Io's is not.

**585** πολύπλανοι πλάναι: n. 565. *Cf.* 576, 788, 820. The compounds of πολυ- emphasize the multiplicity of her sufferings as μυρι- does those of Prometheus.

**586** γεγυμνάκασιν: *cf.* 592 and n. 95.

οὐδ' ἔχω μαθεῖν: But she is in the presence of the revealer (n. 505).

**587** πημονὰς: n. 237.

**588** κλύεις: Zeus does not hear her (582 ff.) and Prometheus may have indulged in another silence (*cf.* n. 437) after 587 if Io paused there, expecting an answer.

βούκερω: indicates the costume.

**589** κλύω: picks up κλύεις—a device often used in the play.

οἰστροδινήτου: *cf.* 580, 681.

**590** θάλπει: 650. Io's madness is the consequence of Zeus' love (879).

κέαρ: On the heart of Zeus, n. 165.

**591** ὑπερμήκεις: n. 585.

δρόμους: recalls γεγυμνάκασιν (n. 586).

**592** στυγητὸς: expresses the obvious consequences of Zeus' ἔρως (591).

πρὸς βίαν: Io is the victim of βία as are Prometheus (74), Hephaestus (15), Typho (353) and Inachus (672). βία is used unsuccessfully against Zeus (208, 357). 380 may indicate that Zeus must be softened gradually, not violently overthrown.

γυμνάζεται: 586, 591.

**593** πατρὸς ὄνομ': Prometheus did not utter her own name. From sympathy for her shame? *Cf.* 640 ff., where, however, αἰσχύνομαι is a v. l. Or was he being formal: *cf. Agam.* 914?

**594** μογερᾷ: 565.

**595** τάλας . . . ταλαίπωρον: Io recognizes that she and Prometheus are both sufferers, though she does not yet know that they are fellow-victims of Zeus.

ἔτυμα: 293. Ocean tries to be to Prometheus what the latter really is to Io, a sort of oracle. For the σοφία of Prometheus, *cf.* 824 ff.

**596** θεόστυτον: n. 116. Especially appropriate because Io's god-sent affliction causes her to rush from place to place: *cf.* οἰστροδινήτου (589)

νόσον: *cf.* 606, 632, 698, and n. 378.

**597** μαραίνει: *cf.* 481, where Prometheus alludes to a similar condition in men.

χρίουσα: n. 506.

κέντροισι: The same animal imagery was applied to Prometheus (323), but he fights back. *Cf.* βοῦταν (568) and βουκόλος (677) of Argus; ἐνέζευξας (578); and σκιρτημάτων below.

φοιταλέοισιν: *cf.* αὖ in 566.

**599** σκιρτημάτων: Especially of young cattle, as in 675; renewed at 1085 (Dawson, 237).

νήστισιν: renews 573.

αἰκείαις: n. 93. Another parallel between Io and Prometheus.

**600** λαβρόσυτος: n. 327. Io merely suffers; Prometheus λαβροστομεῖ. *Cf.* θεόστυτον in 596.

<Ἥρας>: The responsibility for Io's plight is assigned directly to Hera, in the first instance to Zeus.

**601** ἐπικότοισι: Hera is to Io as Zeus is to Prometheus (162).

δαμεῖσα: n. 164. Though Io is Zeus' δάμαρ, her descendant will secure Prometheus' release, thus subduing and overthrowing Zeus' purposes.

**603** μογοῦσιν: Io is more self-centered than Prometheus, in whose presence she asks the question (*cf.* 275). She calls herself μογερά at

565 and 594. Io's thoughts are directed chiefly to herself; Prometheus is concerned chiefly with others: Zeus, mankind and Io.

**604** τορῶς: Always of Prometheus' clear utterances (609, 699, 870).

**605** τέκμηρον: n. 336. He had given her grounds for believing him a seer: 589–593, *cf.* 824 ff.

**606** παθεῖν: n. 158.

μῆχαρ: *cf.* μῆκος (1020) and τέρμα (n. 100).

φάρμακον νόσου: 249, 475, 480, 596.

**607** δεῖξον: n. 170.

οἶσθα: n. 186. εἴπερ οἶσθα would sound as a challenge to one as proud of his knowledge as Prometheus; hence his very full answer to her two questions in the order of their asking.

**608** φράζε: Prometheus willingly reveals to Io (765, 781, 788, 825, 844), but refuses information to Hermes (950, 995).

δυσπλάνῳ: 900. *Cf.* n. 565.

**609** τορῶς: answers 604.

πᾶν: n. 607.

μαθεῖν: n. 505.

**610** ἐμπλέκων: At 1079, "entangle in a net."

αἰνίγματ': 833 and 949. Prometheus as a prophet is similar to the Delphic oracle (662 f.).

ἁπλῷ λόγῳ: n. 46.

**611** δίκαιον: n. 9.

πρὸς φίλους: *cf.* 225.

**612** πυρὸς: Emphasized, as in the Prologue.

δοτῆρ': n. 251. Prometheus answers 561 ff. He does not call himself κλέπτην (n. 8.).

ὁρᾷς: *cf.* 143 ff. He is willing to be gazed at by sympathetic friends.

**613** ὠφέλημα: n. 222. ὠφελέω, first used here of a culture hero, becomes common in that sense in the Hellenistic period: Skard in *SO* **27**: 11–18, 1940.

**614** Reiterates 563. On δίκη: n. 8.

**615** Prometheus recognizes a change in his own behavior, the abandonment of self-pity. Io too ceases lamenting when she shifts to iambic trimeter. *Cf.* 43 f., and παύεσθαι in 11.

**616** πόροις . . . δωρειάν: alludes to 612.

**617** Renews 609.

**618** σήμηνον: n. 295.

φάραγγι: n. 15.

ὤχμασεν: n. 5.

**619** Prometheus forgives Hephaestus, recognizing that he was only the minion of Zeus. Prometheus is more mellow with Io than in the presence of Hermes (975).

βούλευμα: Zeus plots, but his plots will lead to his own undoing (170 and 762):

**620** Renews 614. *Cf.* 112. Prometheus seems reluctant to speak of his crime. The Chorus' query at 194–196 was answered only after a long digression on Zeus' ingratitude (197–225); Io asks the same question three times (563, 614, 620), but must be satisfied with 612 and 619 for answer—of course because the answer had already been given in detail to the Chorus. Verse 615 supplies Aeschylus with a reason for not repeating himself, and 621 closes the subject.

**621** σαφηνίσας: n. 227.

**622** τέρμα: reiterates 606. *Cf.* n. 100.

πλάνης: n. 565.

**623** δεῖξον: renews 607. *Cf.* n. 170.

ταλαιπώρῳ: n. 231.

**624** *Cf.* 248: Snell, *Ph* Suppbd. **20**: 102, 1928

μαθεῖν: renews 609. Prometheus now draws back from his repeated promise (609, 617) to tell Io everything. *Cf.* n. 520.

**625** μήτοι . . . κρύψῃς: *cf.* 501. κρύπτω is the antithesis to all the verbs of revealing: δείκνυμι, σημαίνω, τεκμαίρω, etc.

**626** μεγαίρω: *cf.* 584. In response to Io's pleas Zeus is silent, but Prometheus speaks.

δωρήματος: picks up 616.

**627** γεγωνίσκειν: n. 193.

**628** φθόνος: *cf.* 626, 584.

ὀκνῶ: *cf.* Hephaestus' scruples at 67.

**629** προκήδου: Seems to me to glance at Prometheus' benefactions to man )(Groeneboom. *Cf.* 507 f.

γλυκύ: *cf.* 698 and n. 31.

**631** μοῖραν . . . πόρε: *cf.* 292.

ἡδονῆς: picks up γλυκύ, but with a different feeling: to Io knowledge, however disagreeable, is preferable to ignorance; the Chorus are prompted by innocent, maidenly curiosity. In fact, the

Chorus are the only persons in the play who experience true ἡδονή: n. 31. True pleasure seems restricted to the gods: 494.

**632** νόσον: *cf.* 596.

**633** πολυφθόρους: 820, 643.

**634** τὰ λοιπά: n. 271.

ἄθλων: n. 586.

διδαχθήτω: n. 487.

**635** χάριν: n. 545.

**636** The claims of kinship: 14, 289 ff.

**637–639** Prometheus knows from experience: 136–177.

**640** Io is ashamed to relate her story: 642 and n. 593.

**641 f.** Io inspired to σαφήνεια by Prometheus, speaks like Prometheus. σαφεῖ . . . μίθῳ recalls Prometheus' ἁπλῷ λόγῳ (610), and σαφ- is usually applied to Prometheus (*cf.* 621 and n. 227). *Cf.* 609 and 617.

**642** αἰσχύνομαι: )(Prometheus at 197 f., 436–438.

**643** θεόσσυτον: *cf.* 596.

χειμῶνα: n. 562. Dumortier, *Vocab. méd.*, 69–79, shows that χειμών is used in the Hippocratic corpus of the onset of epilepsy, and that Io's symptoms are those of epilepsy. That does not mean, of course, that Io was epileptic in our sense, but in the Greek sense: laid hold of by a god.

διαφθορὰν: n. 633.

**644** προσέπτατο: n. 115 and 555.

**645** ὄψεις ἔννυχοι: The interpretation of which Prometheus taught to men (485 f.). *Cf.* Nausicaa.

**647** λείοισι μίθοις: nn. 172 and 173. λείοισι is in contrast with the present situations of both Prometheus and Io. Zeus' attempt at πειθώ was followed by threats (667–669), as in Hermes' interview with Prometheus.

**648** παρθενεύῃ: is parallel to παρθενῶνας in 646. *Cf. Odyssey* 6.33 (Groeneboom).

γάμου: n. 764.

**649** ἱμέρου: )(the saving love of Hypermestra at 865.

βέλει: n. 358.

**650** τέθαλπται: n. 590.

**651** 'πολακτίσῃς: Another animal metaphor (Schol.). *Cf.* n. 597.

**652 f.** βαθὺν λειμῶνα: carries on the tone of λείοισι μίθοις (647): pleasant softness.

**654** Δῖον ὄμμα: n. 53 and Thomson on 614 f.

λωφήσῃ πόθου: *cf.* 376. The πόθος of Zeus is not better in its effects on Io than χόλος.

**655** εὐφρόνας: Ironical, as δύστηνος shows. *Cf.* the irony of εὔδαιμον in 647.

ὀνείρασι: *cf.* 485 f.

**656** ξυνειχόμην: may glance at their intercourse, but LSJ[9] give this sense first for Aristotle.

**656 f.** *Cf.* Nausicaa.

γεγωνεῖν: n. 193.

**660** δαίμοσιν πράσσειν φίλα: 10 f. and n. 494.

**662** ἀσήμους: σημαίνειν is a function of Prometheus as prophet, n. 295.

δυσκρίτως: 458, 486.

**663** ἐναργὴς βάξις: *cf.* σαφεῖ . . . μίθῳ (641) and ἐπάργεμα (499).

**664** σαφῶς . . . μυθουμένη: *cf.* 641 and n. 227.

ἐπισκήπτουσα: *cf.* the commands of Zeus (3, 17, 40 f.).

**666** ἄφετον: Animal imagery, *cf.* Thomson *ad loc.*

ἐσχάτοις: Where Prometheus is (1, 418), and where Io's wanderings will end (846).

**667** πυρωπὸν: *cf.* φλογωπός and φλογώψ (253, 498, 791).

**668** κεραυνόν: n. 372.

ἐξαΐστώσοι: 151, 282 and (of Zeus) 910.

**669** πεισθεὶς: Ironical, *cf.* 647 and n. 172.

**671** ἄκουσαν ἄκων: n. 19.

ἐπηνάγκαζε: *cf.* nn. 16, 108.

**672** χαλινὸς: *cf.* 562, and the imagery from harnessing in the Prologue.

πρὸς βίαν: n. 592. Though Inachus' intentions were of the best (660), Zeus seems to prefer coercion.

**673** *Cf.* n. 78.

**674** ὀξυστόμῳ: *cf.* 424, 803 and the eagle.

**675** χρισθεῖσ': n. 566.

ἐμμανεῖ: Prometheus calls Io mad only once (848), though she recognizes her own malady (580 f., 877–886); Hermes calls Prometheus mad (977, 1057), though he is not.

σκιρτήματι: n. 599.

**676** ᾖσσον: *cf.* 837. Contrast the mad frenzy of Io with the Chorus' eager impetuosity (n. 133).

εἴποτον: also 812. Greek concern with water supply.

**677** γηγενὴς: as in 567 emphasizes his monstrous nature, *cf.* Typho (351).

**678** ὀργὴν: n. 80.

**678 f.** *Cf.* n. 568.

**681** οἰστροπλὴξ: *cf.* 878 and 1054.

**682** μάστιγι: n. 597.

ἐλαύνομαι: A process begun by her father (670).

**683 f.** ὅ τι λοιπὸν: n. 271.

σήμαινε: 662 and n. 295.

οἰκτίσας: 629 and 239. Io perceives Prometheus' compassion.

**685** σύνθαλπε: Because of her experience with Zeus (590, 650) Io is suspicious of being deceived.

μύθοις ψευδέσιν: correspond to the λείοισι μύθοις of 647 )(σαφεῖ . . . μύθῳ (641).

**685 f.** *Cf.* 225. The relationship between friends, here and at 610 f., is contrasted with the relationship of a tyrant to his subjects.

**690** δυσθέατα: 69 of Prometheus.

δύσοιστα: reveals the Chorus' sympathy with Io.

**692** ἀμφήκει: *cf.* δίθηκτον (863). Both sympathy and hate can pierce the heart.

κέντρῳ: The Chorus think of the gadfly (597, 682).

**694** ἰὼ ἰώ: as in 576.

**695** πέφρικ': As for Prometheus at 540.

πρᾶξιν: τὰ πραχθέντα (683).

**696 f.** Prometheus mildly rebukes the Chorus for their outburst of sympathetic fear. He does so, first because they have interrupted him when he was about to fulfill the second of their requests (631–634), Io having just fulfilled the first; and second, because Io is destined to find release (706), whence their outburst not only is untimely but will prove inappropriate. This double motive for his words is embodied in πρώ γε στενάζεις, "you groan too soon," *sc.* (1) for worse troubles are to come, or (2) for Io's lot is not so dark as it appears. Prometheus only hints at the second alternative, which becomes clear at 807 ff. His first line refers to the Chorus' final two: στενάζεις to ἰὼ ἰώ; φόβου πλέα to πέφρικα.

τὰ λοιπὰ: n. 271.

προσμάθης: n. 505.

**698** ἐκδίδασκε: n. 487.

τοῖς νοσοῦσι: Prometheus is Io's physician, *cf.* Hippoc., *Prog.* 1 (Dumortier 43 f.). Verses 698 f. fit Prometheus too, as προυξεπίστασθαι shows (*cf.* 101).

γλυκὺ: as in 629, a bitter pleasure.

**699** λοιπὸν: 697.

ἄλγος: ἀλγ- elsewhere of Prometheus (197 f., 238, 245, 261, 435, 934).

τορῶς: n. 604.

**701** κούφως: As befits dealings among friends. *Cf.* βαρύς of Zeus in 17, 77, and n. 685 f.

μαθεῖν: *cf.* 697.

ἐχρῄζετε: The desires of the Chorus, arising from sympathy (245) and innocent curiosity (283 and here) are far different from Zeus' (n. 233).

**702** ἄθλον: n. 95.

ἐξηγουμένης: A Promethean word (214, 446), n. 641 f.

**703** τὰ λοιπὰ: n. 271.

**704** Ἥρας: 592, 600, 900. Once Zeus abandons Io, she becomes Hera's victim.

**705** Ἰνάχειον σπέρμα: He avoids her name, as at 589 f.

**706** τέρματ': n. 100.

ἐκμάθῃς: renews ἐκδίδασκε (698). *Cf.* n. 505. The two compounds with ἐκ- look to Prometheus' very full account of Io's wanderings, and incidentally to his full knowledge (609, 617).

**707–869** On Io's route see J. L. Myres in *CR* **60**: 2–4, 1946.

**708** ἀνηρότους: Connotes lack of civilization (n. 2).

**712** μὴ πελάζειν: n. 125.

**714 f.** σιδηροτέκτονες . . . Χάλυβες: suggests Prometheus three ways: (1) fire makes their τέχνη possible; (2) Prometheus revealed iron to men; (3) *cf.* 133.

φυλάξασθαι: 804.

**716** ἀνήμεροι: *cf.* 462–466.

οὐδὲ πρόσπλατοι: *cf.* 712.

**717** ὑβριστὴν: *cf.* 82. Perhaps the Araxes (Schol.) or the Phasis (Myres, *loc. cit.*). *Cf.* Herodotus I. 189.

οὐ ψευδώνυμον: *cf.* 85. A true name reveals the inner nature: n. 15.

**718** περάσῃς . . . περᾶν: The word connotes endurance to the end (713, 731, 790).

οὐ . . . εὔβατος: *cf.* ἄβατος, the v. l in verse 2.

**720** ὕψιστον: *cf.* 5, 421.

ἐκφυσᾷ μένος: and κροτάφων ἀπ' αὐτῶν (721): Reminiscent of Typho, 366–368.

**721** ἀστρογείτονας: n. 2.

**724** στυγάνορ': The Amazons (also mentioned 415 f.) are the prototypes of the 49 Danaids.

**726** τραχεῖα: Io's route will be as harsh as Prometheus' tormentors (35, 187, 324).

γνάθος: recalls Typho (368), the wedge (64), and the eagle.

**727** ἐχθρόξενος: suggests the Euxine Sea. *Cf.* 716. Indifference to the rights of ξένοι is barbaric, as is the absence of agriculture (708).

μητρυιὰ: alludes to the story of King Phineus' sons (Bacon, quoted by Thomson on 749 ff.).

**728** ἀσμένως: They will assume that Io hates men. In fact, she expresses no hatred, nor even criticism, of Zeus.

**730** θρασυσπλάγχνως: n. 42.

**731** ἐκπερᾶν: n. 718.

**732** λόγος μέγας: i.e., κλέος, which Prometheus promises Io at 834.

**733** Βόσπορος: *cf.* 717 and n. 15.

**736** τύραννος: n. 222. It is Prometheus, the sworn enemy of Zeus, who reminds us that Zeus, not Hera (n. 704), is ultimately responsible for Io's sufferings.

**737** βίαιος: n. 74.

θνητῇ θεὸς: The fundamental antinomy of the play, n. 8.

**738** χρῄζων: nn. 233 and 701.

ἐπέρριψεν: Reminds us of Zeus' thunderbolt (668; 992, 1043).

πλάνας: n. 565.

**739 f.** πικροῦ . . . γάμων μνηστῆρος: A fine, ironic use of the *Odyssey*. The πικρότης seems to fall entirely on Io; but Penelope's suitors were πικρόγαμοι to themselves as well as to others, and Zeus will one day be forced to relent. Another veiled reference to Io's rehabilitation, *cf.* 696.

πικροῦ: n. 178.

γάμων: *cf.* 648.

**742** Io relapses to the mood of 566, 579. Perhaps Thomson is right in assigning this verse to the Chorus (*cf.* 694), for 743 f. are similar to 696 f., Prometheus' answer to the Chorus' former wail of dismay.

**744** τὰ λοιπὰ: n. 271. Prometheus' words suggest that Io's future is hopeless, but *cf.* n. 696 f.

πυνθάνῃ: n. 520.

**746** δυσχείμερον: n. 562.

πέλαγος: n. 184.

δίης: n. 179.

**748** : ἔρριψ': Suicide would have saved her from the wanderings imposed (ἐπέρριψεν, 738) by Zeus. *Cf.* her longing for death (582 ff.); and Prometheus' for concealment (152 ff.), transformed into a proud challenge (1050 ff., NB. ῥίψειε: Prometheus could not commit suicide).

στύφλου πέτρας: *Cf.* Prometheus' rock.

**750** ἀπηλλάγην: n. 316.

**751** Fits Prometheus, as he points out in his reply.

**752** ἄθλους: *cf.* 702.

**753** *Cf.* 1053.

πεπρωμένον: πεπρωμένη is mightier than Zeus (518).

**754** ἀπαλλαγή: 750.

**755** τέρμα: *cf.* 706 and 257. At 258 Prometheus stated that the end of his sufferings would come only if Zeus willed it; here he suggests that his release depends upon the fall of Zeus. That possibility, vaguely hinted at in 519 f., is kept before our eyes through the remainder of the play. *Cf.* nn. 100 and 523.

**756** ἐκπέσῃ: Prometheus conceives Zeus' fall as a violent overthrow (757, 910, 948, 997) analogous to that of Cronus (210, 912, 957). Prefix ἐκ- suggests the θρόνος or ἕδρα of power: 767 and nn. 201, 228.

**757** ἀρχῆς: Io substitutes ἀρχή for τυραννίς, since she understands Prometheus to mean that Zeus will be utterly overthrown. In fact, if Zeus would but abandon τυραννίς, he might retain his ἀρχή, a situation envisaged in 190–192 and perhaps developed in the sequel. See Todd in *CQ* **19**: 61 ff., esp. his n. 2, 1925.

**758** ἤδοι': n. 31.

**760** γαθεῖν (coni. Murray): makes a fine ἴσα πρὸς ἴσα with ἐγεγήθει at 157 (Elmsley's almost certain conjecture).

**761** *Cf.* 171. Perhaps she believes that Prometheus will do the deed, *cf.* 83.

**762** αὐτὸς αὐτοῦ: *Cf.* anadiplosis of θεός (n. 29). Zeus is his own worst enemy. Prometheus' attack on Zeus' prerogatives will attain final fulfilment because of Zeus' own folly. Here, as at 170, the Schol. identify the βούλευμα as Zeus' plan to unite with Thetis. Zeus and Prometheus are plotting against one another: 619, 1055.

**763** σήμηνον: n. 295.

βλάβῃ: n. 196. Io is as considerate towards Prometheus as the Chorus are.

**764** γαμεῖ γάμον: γαμ- occurs 13 times in the play. Four marriages are important. (1) Prometheus' (558): typifies his former happiness, accentuating his present suffering, and shows the proper way for a marriage to be arranged; (2) Io's with Zeus (648, 739): the prime illustration of the nature of Zeus' tyranny; (3) Zeus' intended union with Thetis (909, 947): will lead to his downfall; and (4) the 50 Danaids' to their cousins (855, 859). All the Danaids but one slew their husbands (860 ff.), but Hypermestra laid aside θράσος and hate (865 ff.), whence her marriage becomes a sort of criticism of Zeus' union with Io and of Zeus' tyrannical nature in general. The role of πειθώ in (1) and (2), 560 and 669, likewise illustrates Zeus' tyranny.

**765** Polarity: n. 116.

ῥητὸν: *cf.* 519 ff. and 621.

**767** Paradox: n. 6. A similar paradox (men subdued by their δάμαρτες) occurs at 860 f. Here the Scholia wrongly identify the δάμαρ as Hera: *cf.* n. 762.

ἐξανίσταται θρόνων: n. 756.

**769** ἀποστροφὴ: n. 750. Zeus, like Io and Prometheus, would seek to escape his fate.

**770** This verse appears to indicate the course of events in *Prometheus Unbound:* Zeus releases Prometheus on condition that Prometheus reveal to him what menaces his tyranny (*cf.* 167–177). Such an outcome would be possible only if Zeus and Prometheus were reconciled (190–192). When Prometheus first refers to these matters, his meaning is quite obscure.

**771** ὁ λύσων: n. 27.

ἄκοντος: Io believes that Zeus' will is invincible and inflexible (*cf.* 3 f., 17, 34, 40 f., 50, and 324, 149 ff., 163 ff., 184 f., 333, 376), for she has experienced its constraint (671, *cf.* 19) and knows the evil of Zeus' intentions (651, 738; *cf.* 233 and 619); but Prometheus is convinced that Zeus may some day will his release (177, 192, 258 f.).

**772** χρεών: Here and at 997 = πεπρωμένη (518 f.) and ἀνάγκη (515 ff.).

**773** ἀπαλλάξει: *cf.* 750.

**774** How are the 13 generations to be reconciled with the 30,000 years of Schol. on 94? Thomson (on 800) reminds us that we are not supposed to engage in computations while reading or witnessing a play; but Todd's explanation (63) seems more satisfactory: viz., the 13 generations are, at least in part, divine, not human.

**775** Prometheus, like Delphi (662 f.), has delivered an obscure oracle; and just as a clear word was later given to Inachus, so Prometheus later (920 ff.) interprets his own oracle, but not to Io.

**776** ἐκμαθεῖν: 706, 817, 876.

ζήτει: 262, 316.

**777** She refers to such promises as are given at 609–611, 617, 703–706. *Cf.* n. 520.

**778** Like Delphi, Prometheus prefers an alternative question: *cf.* H. W. Parke and D. E. W. Wormell, *The Delphic Oracle* **1**: 18 f. on the lot-oracle; oracles obviously or probably delivered in answer to alternative questions, **2**, Oracles No. 11, 24, 25, 51, 53, 54, 56, 61, 65, 67, 72, 87, 91, 93, 97, 105, 106 (all before the end of the Persian War). A transparent device that

enables Aeschylus to include in his play all that he wishes to.

δωρήσομαι, δίδου, δίδωμ': n. 251.

**780** τὰ λοιπά: n. 271.

**781** σαφηνῶς: n. 227.

τὸν ἐκλύσοντ': *cf.* 771.

**782–785** The animated, girlish curiosity of the Chorus causes them to intervene on behalf of Aeschylus' narrative, as at 631. They use three words, innocently enough, that bear a graver meaning elsewhere in the play:

χάριν—*cf.* 985. χάρις is possible only among friends.

ἀτιμάσῃς—*cf.* 195, 919. For the Chorus to be deprived of an interesting revelation with regard to the future would be a slight insult indeed compared to those exchanged by Zeus and Prometheus.

ποθῶ—*cf.* 654. Innocent inquisitiveness )(Zeus' lecherous eye.

**784** γέγωνε: n. 193.

τὴν λοιπὴν πλάνην: nn. 271, 565.

**785** τὸν λύσοντα: *cf.* 781.

**786** προθυμεῖσθ': 630.

ἐναντιώσομαι: )(his attitude to Zeus, Ocean, Hermes, and *cf.* κούφως (701).

**787** γεγωνεῖν: picks up 784.

πᾶν: 609, 617, 641.

**788** πολύδονον: n. 585.

**789** *Cf.* 460 f. and 535.

**790** περάσῃς: n. 718.

ἠπείροιν: picks up 735.

**792** παρεῖσα (Heimsoeth and Murray, ed. 1. Ed. 2 reads περῶσα.): Emended by Platnauer in *Humanitas* (Coimbra) **4**: 71–75, 1952, to πάρεισθα, with some improvement to the geography.

**796** οὔθ' ἥλιος προσδέρκεται: *cf.* primitive man (450–453), )(Prometheus at 22 f. and 91. The sun is conceived as a great eye (*cf.* 795).

**796 f.** The Phorcydes are untouched by the alternation of day and night )(Prometheus in 22–25.

**799** βροτοστυγεῖς: Like Zeus (231 ff.).

**800** The Gorgons typify the evils of staring: n. 146.

**802** θεωρίαν: n. 302. Io's later encounters with supernatural monsters (790–807) should prove more dangerous than her earlier adventures among uncivilized men, but Prometheus' tone grows less ominous. Here she is a tourist, though among disagreeable (δυσχερῆ) scenes; at 814 she becomes a colonizer. The tone changes because Io is nearing salvation.

**803** ὀξυστόμους: n. 674.

ἀκραγεῖς: Paradox.

κύνας: Hunting dogs—572, 1022; 73, 277, 393, 1041; 835 (σαίνειν).

**804** φύλαξαι: *cf.* 390, 715.

**807** μὴ πέλαζε: n. 125.

τηλουρὸν: n. 1.

**812** εὔποτον: *cf.* 676.

**814 f.** ἀποικίαν . . . κτίσαι: n. 802.

πέπρωται: *cf.* n. 772. Zeus and his victims are all alike dominated by Pepromene.

**815** τέκνοις: 772, 774.

**816** ψελλόν τε καὶ δυσεύρετον: *cf.* obscure oracles at 486, 662, 775, and n. 59.

**817** ἐπανδίπλαζε: As Inachus did (658 ff.), and as sometimes happened at Delphi: e.g., Herodotus VII.140 f.

σαφῶς: n. 227.

ἐκμάνθανε: n. 776.

**818** His grim humor suits the tone of 790 ff.: nn. 802 and 31.

**819** τι . . . λοιπὸν: 683 f. and n. 271.

**820** γεγωνεῖν: n. 193.

πολυφθόρου πλάνης: *cf.* 788.

**821** χάριν: *cf.* n. 782–785.

**822** δὸς: *cf.* 778–780.

ἠτούμεσθα: At 785. *Cf.* 617.

**823** πᾶν: *cf.* 787.

τέρμ': n. 100.

**823 f.** *Cf.* 447 f. Prometheus has enlightened Io as he did primitive man.

**826** τεκμήριον . . . δοὺς: As the Delphic Oracle sometimes did: e.g., Hdt. I. 46, 2 ff.; and as Prometheus had done on a small scale at 589 ff. *Cf.* n. 336.

**827** Perhaps this portion of the narrative was used in the sequel: Myres in *CR* **60**: 3, 1946. Prometheus was aware that prolix discourse can be annoying (1001).

**828** *τέρμα σῶν πλανημάτων*: 823 and n. 100. Prometheus now adds a portion of Io's itinerary that follows 807*a*.

**830** *Δωδώνην*: Consulted by Inachus (658).

**832** *τέρας . . . ἄπιστον*: So is Heracles (921).

**833** *λαμπρῶς*: Io will accept the blaze of publicity that surrounds her )(*κάλυψον*, 582.

*οὐδὲν αἰνικτηρίως*: n. 816, and 610, 949.

**834** *κλεινὴ*: *cf.* 732.

*δάμαρ*: n. 6.

**835** *προσσαίνει*: *cf.* n. 803.

**836** *οἰστρήσασα*: Driven by the *οἶστρος* of 566 and 879.

**837** *ἦξας*: 676.

**838** *χειμάζῃ*: n. 562.

*δρόμοις*: 883 and n. 591.

**840** *σαφῶς*: 817. *Cf.* 967.

*ἐπίστασ'*: n. 374.

*Ἰόνιος*: 733 and n. 15.

**841** Another form of *κλέος*: *cf.* 834.

**842** *σημεῖα*: *cf.* nn. 295 and 826.

**843** *δέρκεται*: The preternaturally clear vision of Prometheus is analogous to Argus' (678 f.), but of a higher sort.

**844** *τὰ λοιπά*: n. 271. Prometheus now continues where he left off at 815.

**846** *ἐσχάτη χθονός*: *cf.* 1 and nn. 666, 807.

**848** *ἔμφρονα*: *cf.* 673. Zeus will apparently act voluntarily: n. 771.

**849** *ἑπαφῶν . . . Ἔπαφον* (851): n. 840.

*ἀταρβεῖ*: Zeus as a tyrant causes fear and uses fear to control his subjects: 898, 932, 960, and Cratos' tone in the Prologue. Here Zeus appears to have laid aside his tyrannical character. This action may prefigure the release of Prometheus. On the problem of Zeus' character see T. B. L. Webster in *Fifty Years of Classical Scholarship*, edited by M. Platnauer. On fear: n. 41.

**851** *κελαινὸν*: Like the natives (808), *cf.* 22 f.

**854** *οὐχ ἑκοῦσ'*: Other evil deeds of constraint at 19, 671.

**855** *γάμον*: n. 764.

**858** *θηρεύοντες . . . θηρασίμους*: Other metaphors from hunting involve dogs (n. 803) and nets (n. 263 f.).

**860** *θηλυκτόνῳ*: A paradox, *cf.* Clytemnestra.

**861** *δαμέντων*: By their intended *δάμαρτες*! *Cf.* n. 6. Thus Zeus' power will be checked through Io.

*θράσει*: n. 42. It is a striking instance of *θράσος* for a woman to kill a man.

**863** *δίθηκτον*: n. 692.

**864** *ἐχθροῖς*: Especially Zeus (972 f.) and *cf.* *Κύπριν* in 650. A veiled reference to Zeus' union with Thetis (Thomson).

**865** *παίδων ἵμερος*: Probably go together, "desire for children," *cf.* *τέξει* at 869. So Méautis, 85; Mazon; Rackham in *CR* **41**: 9, 1927; Harrison, 8. *ἵμερος* here leads to good )(649.

*θέλξει*: )(173. The story of Hypermestra, told at some length, shows how Zeus and Prometheus might be reconciled, if Zeus would abandon violence (thus renouncing *τυραννίς*), and if Prometheus too would relent. As Pohlenz (I, 75) envisages the denouement, Zeus renounces his love for Thetis and becomes a perpetual ruler; he renounces his hate for Prometheus and becomes an enlightened ruler. *θέλξις* is a form of *πειθώ* (n. 172).

**866** *σύνευνον*: The story of Hypermestra, besides its implications for Zeus (*cf.* preceding n.), is a commentary on Zeus' dealings with Io, as the repetitions of *ἵμερος* (649 and 865) and *Κύπρις* (650 and 864) make clear.

*ἀπαμβλυνθήσεται*: Her sword (863) will lose its edge. *Cf.* n. 311.

**867** *γνώμην*: Of Prometheus (543) and Zeus (1003). Prometheus stubbornly goes his own way, and Zeus strives to inspire fear (*cf.* 849). Hypermestra could teach them both.

*δυοῖν δὲ θάτερον*: A Delphic choice, *cf.* 778.

*βουλήσεται*: A free choice (Perrotta, 40), which reveals her character. *Cf.* 177.

**868** *κλύειν*: Hypermestra was concerned with her *κλέος* (nn. 841, 241), but chose the better part. Prometheus and Zeus would fear losing face if

they backed down and exhibited ἀνάλκεια, which is less disgraceful in a woman.

μιαιφόνος: Epithet of Ares in Homer—Bergson, 121.

**870** μακροῦ λόγου: *cf.* 827. The μακρὸς λόγος is the *Supplices* trilogy.

τορῶς: n. 604.

**871** θρασὺς: n. 42.

**872** κλεινός: Links Heracles to the story of Hypermestra (κλύειν, 868).

**873** λύσει: is the culmination of a series of hints that began as early as 27.

χρησμὸν: Themis too was oracular, *cf.* 211.

**875 f.** *Cf.* n. 520.

μακροῦ λόγου: 870. The *Prometheus Unbound*.

ἐκμαθοῦσα: n. 776.

κερδανεῖς: Recalls 747 and 777.

**877 ff.** Exit Antigonus, chased by a bear.

**878** σφάκελος: Medical technical term, echoed at 1045.

φρενοπληγεῖς: *cf.* 1054, 681.

**879** μανίαι: *cf.* 977 and 1057. Hermes believes Prometheus as mad as Io actually is. Her νόσος is μανία, Prometheus' ἀθυμία (474), an ailment of which his conversation with Io completely cures him.

θάλπουσ': Intensely and bitterly ironic. Her madness is the consequence of Zeus' love (590, 650).

οἶστρου: *cf.* 566 (χρίει in both places). Io exits as she entered.

ἄρδις . . . ἄπυρος: A riddle or kenning.

**881** φόβῳ: At the sudden renewal of her torments. Even Prometheus is terrified (1090) as he is hurried beneath the earth. *Cf.* n. 41.

λακτίζει: The animal imagery returns: shying (882), whirling wheels, and ἔξω . . . δρόμου. Io became an animal when she was turned out (ἄφετον, 666) by her father. In the Io-scene the animal imagery is concentrated in the lyric passages, here at the end and when she first enters: 562, 568, 572, 578, 597, 599; *cf.* also 677.

**882** ἑλίγδην: *cf.* 1085, 1092, where all are swept away like Io.

**883** ἔξω . . . δρόμου: The metaphor of these verses is usually considered to be drawn from racing: *cf.* 591, 838: but Dawson (238) sees here the beginning of a new metaphor, which continues to the end of the speech, drawn from a boat swept into the shallows, where the oars flail the waves in disorder. Might ἔξω . . . δρόμου be a bridge common to both metaphors: *cf.* n. 920?

**884** πνεύματι μάργῳ: like ἑλίγδην (882) is echoed at the end (1086 f.).

γλώσσης ἀκρατής: One of the usual symptoms of divine possession: Dumortier, *Vocab. méd.*, 32 f. Prometheus too is γλώσσης ἀκρατής, but in a different sense.

**886** ἄτης: *cf.* 1072, 1078.

THIRD STASIMON: 887–906

**887** σοφὸς: This theme, developed here in the Chorus' reflections on Io's fate, is used again in the scene with Hermes (Thomson): 944, 1011, 1038 f.

**888** γνώμᾳ: n. 527.

**890** Men and gods are on separate planes: *cf.* 737 and n. 8. This verse is condensed in the phrase ὁμαλὸς ὁ γάμος (901). Schol. on 886 compare the tale of Pittacus that was retold by Callimachus, Epigram 1 (Pfeiffer).

**891** πλούτῳ διαθρυπτομένων: *cf.* 466.

**895** Μοῖραι: *cf.* 694. The Chorus are thinking of Io's fate, as is made clear by λεχέων, etc. (*cf.* 651).

**897** πλαθείην: n. 125.

**898** ταρβῶ: n. 849.

ἀστεργάνορα: Io is like the Amazons (724), and the inverse of Hypermestra (*cf.* ἄνδρ' in 862).

παρθενίαν: Used of the Amazons (416), and of Io elsewhere (588, 608, 646, and 648).

**899** εἰσορῶσ': n. 146.

**900** δυσπλάνοις: As in 608.

Ἥρας: 704, 738.

ἀλατείαις πόνων: n. 267. The phrase is the equivalent of δυσπλάνοις.

**901** ὁμαλὸς: n. 890.

**902** ἄφοβος: *cf.* 881 and n. 41.

δέδια: n. 182.

**903** [θεῶν] ἔρως: *cf.* 591.

ἄφυκτον ὄμμα: n. 654. The phrase fits Argus too.

**904** Oxymora, as in 545.

ἄπορα: )(the gifts of Zeus (934) with those of Prometheus (616, 631, 946).

**906** Chorus have observed the fates of Prometheus and Io.

EXODOS: 907–1093

**907 ff.** Prometheus angered by the spectacle of Io's unmerited sufferings.

**907** αἰθάδη: n. 64.

**908** ταπεινός: n. 320.

**909** γάμον γαμεῖν: alludes to Zeus' union with Thetis, n. 764.

τυραννίδος: n. 10.

**910** ἄιστον: n. 232. (So Sikes and Willson.)

ἐκβαλεῖ: 912 and n. 756.

**910 f.** ἴσα πρὸς ἴσα. On κρᾶναι *cf.* n. 211.

**913** μόχθων: n. 314.

ἐκτροπὴν: nn. 316, 769.

**913 ff.** As once before, 216 ff.

πλὴν: occurs eight times in this play (see Index), six times in all the other plays of Aeschylus, emphasizing the unique vs. the usual (*cf.* Morel in Bursian, **234**: 82).

δεῖξαι: n. 170.

σαφῶς: n. 227.

**915** χῷ τρόπῳ: *cf.* 875.

πρὸς ταῦτα: defiant or threatening, as at 992 and 1043; used by Hermes at 1030, and *cf.* 1000.

**916** θαρσῶν: n. 42.

καθήσθω: *sc.* on his throne, from which he will be ejected—910, 912, and n. 756.

κτύποις: Destined to be surpassed (923). One of the menacing sounds (n. 115).

**917** πιστός: Since he does not trust his friends (225).

πύρπνουν βέλος: *cf.* nn. 358 f., 371. Prometheus is thinking of Typho's fate.

**919** πεσεῖν . . . πτώματ': 910, 912.

ἀτίμως: n. 195.

**920** παλαιστὴν: *cf.* 528. Prometheus refers to Thetis' son, foreshadowed as early as 166. Note the series ἐκβαλεῖ (910), ἐκπίτνων (912), πεσεῖν (919) and παλαιστήν. πεσεῖν is where the metaphor shifts from a fall from the throne to a fall in wrestling. The word also fits Heracles, who will help to secure Prometheus' freedom in the sequel: i.e., Zeus is fated to be out-wrestled one way or another.

**921** αὐτὸς αὐτῷ: renews 762.

τέρας: n. 352.

**922** εὐρήσει: Prometheus associates himself with Thetis' son. Typho fought Zeus' fire (358 f.) with fire (367 ff.) which harmed only the Sicilian farmers; here Prometheus has an effective revenge in mind. κρείσσον' looks at Zeus' κράτος: 35, 149 f., 213, 324, 403, 519 (the turning point), 528, 937, 939, 948, 955 sim. 149 (because Hermes does not comprehend that Zeus' supremacy is unsure). The κρατεραῖς γυιοπέδαις (167 f.) are a manifestation of Zeus' supremacy, as is Cratos.

**923** κτύπον: 916.

**925 f.** Why should Poseidon too be attacked? Traditional motif? Scholia suggest because he is Zeus' brother and could help Zeus (*cf.* 1048–1050). Perhaps Aeschylus included him because he and Zeus were rivals for the hand of Thetis. Or was it because Zeus had attacked Prometheus' brothers? If so, why is Hades not included? (Gods afraid to meddle with Hades lest the dead swarm everywhere?)

**926** μαθήσεται: nn. 10 and 62.

**927** Only under a tyranny is δουλεύειν (not ἄρχεσθαι) the opposite of ἄρχειν. We are carried back to a theme of the Prologue: 16 f., 40 f., 50—Snell in *Ph* Suppbd. **20**: 106 f., 1928.

**928** ἐπιγλωσσᾷ: n. 294.

**929** Prometheus prides himself on his prophetic power. With τελεῖται *cf.* 511.

**930** προσδοκᾶν: 988, 1026. The end of the play looks forward )(retrospection in the beginning. Aeschylus' very elaborate use of the past, the present and the future in this play is discussed by Thomson: edition, *passim*; *Aeschylus and Athens*, 328–330.

δεσπόσειν Ζηνός: A paradox to the Chorus. The Titans had hoped to master Zeus (208).

**931** δυσλοφωτέρους: n. 27.

πόνους: n. 267.

**932** ταρβεῖς: n. 849.

**933** In his mood of exultant defiance Prometheus boasts of what was formerly (753) a

cause of grief (Thomson), and fears nothing )(127 and 1090.

**934** ἄθλον: n. 95.

ἀλγίω: 197, 238.

πόροι: n. 904.

**935** προσδοκητά: *cf.* 930 and 101.

**936** προσκυνοῦντες: As before an Oriental potentate.

Ἀδράστειαν: In this play little different from μοῖρα, ἀνάγκη, πεπρωμένη and -μένον (see Index).

σοφοί: *sc.* and not merely prophets (Thomson). In their mild way the Chorus are critical (n. 62).

**937** Prometheus, stung by their criticism, retorts sharply, as at 392.

σέβου: *cf.* 543.

προσεύχου: Prometheus knows that Io's prayer (584) went unanswered. His own prayer to Zeus (1043–1052, 1057) is, in fact, a challenge.

θῶπτε: Prometheus deems the Chorus like their father (388, 390, 374) for counselling cooperation.

κρατοῦντ ἀεί: *cf.* 519. Intentionally ambiguous: to Prometheus Zeus, the perpetual ruler, is but the present ruler (939).

**938** μέλει: *cf.* 3.

**939** δράτω: Zeus at present has the initiative, *cf.* 50 and n. 18.

κρατείτω: n. 922.

βραχὺν and δαρὸν . . . οὐκ: are Prometheus' retort to the uses of μυρι- (n. 94).

**940** ὅπως θέλει: αἰθάδης, 907 and n. 64. )(177.

ἄρξει: n. 757.

**941** τρόχιν: *cf.* n. 36 and Scholia 940.

**942** τοῦ τυράννου τοῦ νέου: n. 35. Perhaps Prometheus implies that what has recently begun might presently end.

**943** καινὸν: is what one would expect of the servant of such a tyrant.

**944** σοφιστήν: One of several references to the Prologue in this scene, *cf.* Thomson on 976 ff. Hermes assumes the tone of Cratos (62), but Prometheus' mood is utterly changed.

πικρῶς ὑπέρπικρον: *cf.* n. 178 and λαβροστομεῖ in 327.

**945** ἐξαμαρτόντ': n. 9.

θεοὺς ἐφημέροις: *cf.* 737.

**946** πορόντα: )(Zeus in 934.

τιμάς: n. 30.

κλέπτην: n. 8.

**947** πατὴρ: n. 4.

ἄνωγε: And Hermes apes him at 1037.

κομπεῖς: *cf.* Typho's fate (361).

γάμους: Zeus must have heard 907 ff. *Cf.* 312 f.

**948** αὐδᾶν: As in 766.

ἐκπίπτει κράτους: *cf.* 912. The throne is one manifestation of κράτος.

**949** αἰνικτηρίως: n. 610.

**952** μαλθακίζεται: n. 79.

**953** σεμνόστομος: Prometheus himself is σεμνός (521 ff.).

**954** ὑπηρέτου: Other insults in 941, 942, 943 (= ἄγγελος, *cf.* 969), 966, 983, 986: Hermes no better than a slave!

**955** νέοι: *cf.* 939 f., nn. 35 and 942.

κρατεῖτε: recalls 939.

**956** ἀπενθῆ πέργαμ': Zeus and his minions imagine that the citadel of Olympus, which Typho sought to storm (357), will ever be free from woe. Headlam's emendation (ἀπερθῆ), which does away with the Castle of Delight, seems quite unnecessary: *cf.* ἀπένθητος in *Agam.* 895, *Eum.* 912, and ἀπένθεια (emend. Blass) in *Agam.* 429.

**957** δισσοὺς: Uranus and Cronus.

ἐκπεσόντας: Ejected from the citadel, rather than from the throne (948).

**959** αἴσχιστα: *cf.* 919.

**960** ταρβεῖν: n. 849.

ὑποπτήσσειν: n. 29.

**962** Answers 950 f.

ἐγκόνει: Same stem as διάκονος (942).

**963** Contrast Prometheus' treatment of Io and the Chorus.

**964** αἰθαδίσμασιν: n. 64.

**965** σαυτὸν: So Prometheus on Zeus at 762, 921.

πημονὰς: n. 237.

καθώρμισας: carries on the metaphor of the storm (133 ff., 190, 885 f.)—Mielke, 56.

**966** δυσπραξίαν: *cf.* 264 f., 695.

**967** σαφῶς ἐπίστασ': *cf.* 840 and nn. 374, 227.

**968** λατρείειν: Sarcastic reference to 966, but Prometheus practices ἐλευθεροστομία.

**969** πιστὸν: n. 917.

**970** *Cf.* n. 82. Prometheus feels justified because Zeus was guilty of hybris first: del Grande, 100. Jones in *CR* N.S. **5**: 16, 1955, gives the verse to Hermes and puts it after 974, doing away with Reisig's lacuna before 970.

**971** χλιδᾶν: Hermes makes the accusation that Prometheus believed the Chorus might make at 466.

**972 f.** Wish similar to 864.

**973** ἐχθροὺς: *cf.* 67 and n. 388.

ἴδοιμι: *cf.* 118, 157, etc.

**974** ἐπαιτιᾷ: The fault is Prometheus' own (see Index, *s.v.* αἰτία, αἰτίαμα), *cf.* 762.

**975** ἁπλῷ λόγῳ: n. 46. In his exultant defiance Prometheus transforms 120 ff.

**976** παθόντες εὖ: Opposite to δυσπραξίαν (966, 264 f.); *cf.* χλιδᾶν (971 f.) and 956.

ἐκδίκως: *cf.* 1093 and )(266–270. Prometheus no longer speaks of his ἁμαρτία.

**977** κλίνω: not ὁρῶ, for Prometheus is reduced to words (Schol.).

μεμηνότ': *cf.* Io, whom Prometheus treated considerately.

νόσον: n. 378.

**978** *Cf.* 384.

στυγεῖν: n. 37.

**979** *Cf.* n. 42.

πράσσοις καλῶς: n. 976.

**980** οὐκ ἐπίσταται: To Prometheus Zeus seems to lack understanding of much more than ὤμοι. *Cf.* n. 374.

**981** ἐκδιδάσκει: Time performs the function of Prometheus, nn. 62, 487. On Prometheus and Zeus, both as learners (*cf.* n. 505), see Thomson, 12; Peretti in *Antike* **20**: 36 f., 1944. Verses 980 f. prefigure Zeus' reform: Case in *CR* **18**: 99 f., 1904, quoting a letter of Dissen published in 1824 )(Farnell in *JHS* **53**: 47 f., 1933.

**982** σωφρονεῖν: Only other occurrence of σωφρο- in the play at 328, but much of Chorus' and Ocean's advice is directed that way.

οὔπω . . . ἐπίσταται: Retort to 981 (and 980). If time will teach Zeus the meaning of ὤμοι, it will also teach Prometheus σωφροσύνη.

**983** To be followed by 986, putting 984 f. after 978? Platnauer in *Humanitas* (Coimbra) **4**: 71–75, 1952.

**984** As Prometheus warned him at 963.

**985** τίνοιμ' . . . χάριν: nn. 545, 112.

**986 f.** A striking example of a common device: Prometheus picks up the word παῖς, but in a different sense.

ἀνούστερος: *cf.* νωθέστερος (62). Hermes, the visible representative of Zeus, is given the same treatment (981).

**988** προσδοκᾷς: n. 930.

πεύσεσθαι: 963.

**989** αἴκισμ': n. 93.

μηχάνημ': *cf.* 59, 469.

**990** γεγωνῆσαι: n. 193.

**991** χαλασθῇ: n. 58.

λυμαντήρια: *cf.* 148 and the λύματα of Io (691).

**992** φλόξ: Which Prometheus is confident will one day be surpassed (922). *Cf.* 1017.

**994** ταρασσέτω: Done at 1088.

**995** γνάμψει: n. 163.

φράσαι: n. 608.

**996** χρεών: *cf.* 772, 970.

**997** ἀρωγά: 267. Prometheus' talk can help him no more than men can.

**998** βεβούλευται: "I have considered the situation thoroughly" introduces the theme of εὐβουλία, which runs from 1012 to 1039.

**999** τόλμησον: nn. 14 and 42. A jibe at Prometheus' θράσος: Prometheus being as he is, ὀρθῶς φρονεῖν would cost him much θράσος.

μάταισ: n. 36.

**1000** παρούσας: n. 271.

ὀρθῶς φρονεῖν: εὐβουλία (1035, 1038). Hermes suggests that Prometheus, who is δεινὸς βολεύεσθαι (*cf.* 59, 998), give up his βουλεύματα (204, 1055, 219) and adopt εὐβουλία (compliance with Zeus' will): that is, that he transform himself mentally. *Cf.* Io's transformation (673).

**1001** ὀχλεῖς: 827.

μάτην: recalls the Ocean-scene (293, 329, 342), as κῦμ' shows. Ocean's talk was no more significant than the splashing of his own billows.

παρηγορῶν: *cf.* 646. Zeus uses Hermes to work on Prometheus as he used dreams to work on Io.

**1003** φοβηθεὶς: nn. 849, 933, 41.

θηλύνους: Like the Chorus (who might have weakened Prometheus: Méautis, 90) and Io. *Cf.* μαλακογνώμων of Zeus (188).

**1004** λιπαρήσω: n. 520.

στυγούμενον: 37, 978.

**1005** γυναικομίμοις: *cf.* θηλύνους (1003).

**1006** τοῦ παντὸς δέω: *cf.* 961.

**1007** Picks up 1001.

**1008** τέγγῃ . . . μαλθάσσῃ: n. 79.

**1009 f.** Taming animals: nn. 4, 81, 462.

βιάζῃ: Prometheus' response to Zeus' βία.

μάχῃ: i.e., Prometheus θεομαχεῖ.

**1011** σφοδρύνῃ: On excess, n. 72. )(982.

ἀσθενεῖ σοφίσματι: Converse of Prometheus' belief, 204–213 and n. 62. ἀσθενεῖ is the antithesis to βιάζῃ and μάχῃ; σοφίσματι to εὐβουλία, which the Chorus consider the true wisdom (1038).

**1012** αἰθαδία: *cf.* 964 and n. 64.

**1013** οὐδενὸς μεῖζον σθένει: repeat ἀσθενεῖ.

**1014** πεισθῇς: The tyrant's πειθώ is a thin veil for κράτος, n. 669.

**1015** χειμὼν: *cf.* 965 and n. 563.

τρικυμία: *cf.* 746, 1048–1050. This threat may have been called forth by Prometheus' simile in 1001.

**1016** ἄφυκτος: *cf.* 903.

**1017** φλογὶ: n. 992.

**1018** πατὴρ: n. 4.

κρίψει: As Prometheus wished (152 ff.), and Io (582), and as was done to Typho and Atlas.

**1019** ἀγκάλη: n. 350.

**1022** κίων: *cf.* 372.

λάβρως: n. 327.

**1024** ἄκλητος . . . δαιταλεὺς: grim humor, n. 31.

**1025** ἦπαρ: The seat of χόλος, which Prometheus must lay aside n. 370: Finley, 228, and before him, Groeneboom on 23 f.

ἐκθοινήσεται: carries on the metaphor of the feast.

**1026–1029** D. S. Robertson in *JHS* **71**: 150–155, 1951, connects these verses with two passages in Apollodorus to show that Heracles shot the eagle, assumed Chiron's immortality, and Prometheus was released.

**1026** μόχθου: n. 314.

τέρμα: n. 100.

προσδόκα: n. 930.

**1027** διάδοχος: n. 464.

**1028** ἀναύγητον: *cf.* 453; 91 and 152.

**1029** Ταρτάρου: 154.

βάθη: Opposite of his present position, n. 18.

**1030** βούλευ': nn. 1000 and 762. Prometheus must begin to plan in a new way.

**1031** κόμπος: 947.

**1032** ψευδηγορεῖν: Neither does Prometheus (685).

ἐπίσταται: nn. 980–982.

**1033** The ἔπη will become ἔργα. All five occurrences of ἔπος are near the end of the play, see Index. Is it because the whole play involves unusually little action (*cf.* n. 977) and now ἔργα impend?

τελεῖ: )(511–520.

**1034** πάπταινε: 334.

φρόντιζε: recalls 1000.

αἰθαδίαν: n. 64. The burden of the whole speech is the contrast between αἰθαδία and εὐβουλία.

**1035** εὐβουλίας: refers back to βούλευε (1030) as ὀρθῶς φρονεῖν (1000) to βεβούλευται (998). Davison in *TAPA* **80**: 73–77, 1949, sees a reference to Protagoras.

**1036** ἄκαιρα: n. 523. Last speech of the Chorus before their conversion, of which there is no indication. Prometheus lacks the qualities that they see in Hermes: Peretti in *Maia* **4**: 35, 1951.

**1037** ἄνωγε: 947.

**1039** πιθοῦ: n. 1014. σοφῷ, etc. is the basis of all the insults to Prometheus' wisdom, 62, etc.

**1040** εἰδότι: Prometheus' foreknowledge showed him the eagle at 124, the upheavals (1016 ff.) at 992 ff. *Cf.* 441 f.

ἀγγελίας: 943, 969.

**1041** ἐθώυξεν: Strident advice resented at 73 f., 277, 393.

πάσχειν . . . κακῶς: *cf.* 976.

**1042** οἰδὲν ἀεικὲς: Prometheus now accepts his torments as a natural part of war with Zeus, *cf.* n. 93.

**1043–1052** Prometheus' prayer (*cf.* 1075 and n. 937). )(582–584.

**1043** ῥιπτέσθω: Of the thunderbolt also in 992, to which Prometheus' only counter-weapon is words (312, 932).

**1044** ἀμφήκης: The relation of the 49 Danaids to their husbands (863) represents Zeus' relation to his subjects, and Hypermestra's conversion showed a better way.

αἰθὴρ: The scene of Prometheus' punishment (88, 1092).

**1045** σφακέλῳ: n. 878. Another of the many parallels between Prometheus and Io, n. 1.

**1046** ἀγρίων ἀνέμων: 884, 1085 f.

**1048–1050** assume that Poseidon will cooperate with Zeus, *cf.* 924 f.

τραχεῖ: n. 35 and *cf.* 726. Nature is τραχύς when working for Zeus.

**1050 f.** κελαινὸν Τάρταρον: *cf.* 1028 f., and) (the tone of 152 ff.

ῥίψειε: 748. Io and Prometheus again.

**1052** ἀνάγκης . . . δίναις: n. 108.

**1053** *Cf.* 933.

**1054** φρενοπλήκτων: n. 878. Io and Prometheus.

**1055** βουλεύματ': It is clear to Hermes that his advice (1034 f., 998–1000) was not heeded, as Ocean's was not (387).

**1056** παραπαίειν: 581.

**1057** εὐχή: 1043–1052.

χαλᾷ: Foreshadows Prometheus' release (n. 58).

μανιῶν: *cf.* 879. The parallels between Io and Prometheus are especially abundant in the closing lines of the play.

**1059** συγκάμνουσαι: *cf.* 414.

**1061** ἠλιθιώσῃ: Hermes warns the Chorus of a fate similar to Io's (673), as the next verse proves.

**1062** μύκημ': *cf.* 1082, the lowing of cattle. Dawson detected this parallel )(Mielke, 89.

ἀτέραμνον: Thunder is the manifestation of Zeus' wrath (190).

**1063 f.** Hermes' arts of πειθώ have failed. The Chorus are suddenly converted, like Hypermestra, so that Zeus and his minions are alone against the world: Maddalena, 151 f., n. 13. Chorus now (unlike 526 f., 904 f.) have the courage to do the right (1066). Hermes was urging Prometheus to this type of courage at 999.

πείσεις: *cf.* 1014.

**1065 f.** What finally converted the Chorus was Hermes' use of a threat when he was pretending to persuade.

**1068** προδόταν: They absolve Prometheus of the charge of treachery, n. 38.

**1069** νόσος: *cf.* 685 f.

**1069 f.** )(225. Chorus are repudiating the disease of tyrants.

**1072** ἄτης: *cf.* Io (886), who was hunted by Argus (572).

θηραθεῖσαι: starts the image of birds caught in a net (ἀπρόοπτον πῆμα, δίκτυον): Thomson. *Cf.* Io (572), Danaids (858); but Argus and the Aegyptiads met violent deaths.

**1074 f.** Zeus uses some of his insincere πειθώ first: *cf.* 669, 1014–1025. But Zeus may himself be moving towards his ἀπρόοπτον (contrast Prometheus) πῆμα. *Cf.* 680.

**1075 f.** αὐταὶ . . . αὐτάς: Of Zeus at 763, 921. εἱδυῖαι: classes them with Prometheus (1076). Voluntary choice, *cf.* 1067.

**1078** ἀπέραντον: suggests Tartarus (153). In his 2nd ed., however, Murray prefers ἀπέρατον, the reading of M.

δίκτυον: 181, 263, and n. 1072. They voluntarily join Prometheus in the net.

ἄτης: 1072.

**1079** ἐμπλεχθήσεσθ': carries on the net-image.

ἀνοίας: Hermes, offended by Prometheus' taunt (987), classes the Chorus with Prometheus (1054–1057).

**1080** ἔργῳ κοὐκέτι μύθῳ: n. 1033.

**1081** σεσάλευται: Ship at sea, storm-tossed? (Dawson, 238.) *Cf.* n. 965.

**1082** ἠχώ: n. 115.

παραμυκᾶται: n. 1062.

**1083** ἕλικες and εἱλίσσουσιν (1085, 1092); *cf.* 882.

**1085** σκιρτᾷ: *cf.* 599, 675.

**1085 f.** ἀνέμων πνεύματα: cf. 884. All these reminiscences of Io's fate pointed out by Dawson.

**1087** στάσιν: 200.

**1088** Fulfills 1048–1050.

**1089** ῥιπὴ: )(126.

**1090** φόβον: Prometheus reverts to the mood of 115–127.

φανερῶς: )(λαθραίως at 1077.

**1092** αἰθὴρ: *cf.* 88. Prometheus ends as he began; so Io, 877 ff.

**1093** More concentrated than 88–95, for Prometheus is pressed for time.

ἔκδικα: like ἐκδίκως (976) shows Prometheus' increased confidence in his own righteousness )(112, etc. Prometheus is now as sure of the justice of his position as his opponents were of theirs at 30.

πάσχω: n. 159. *Cf.* 92; but the doubt of 98–100 is in a fair way to being removed.

## INDEX OF SOME IMPORTANT WORDS USED IN *PROMETHEUS BOUND*


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# THE ORIGIN, EVOLUTION, DISPERSAL, AND GEOGRAPHICAL DISTRIBUTION OF THE CUBAN POECILIID FISHES OF THE TRIBE GIRARDININI*

LUIS RENE RIVAS

Associate Professor of Zoology and Curator of Fishes, University of Miami

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## INTRODUCTION

DURING the past eighteen years, the author has devoted much time and effort to the study of the Cuban poeciliid fishes of the tribe Girardinini. Numerous field trips covering the island of Cuba and the Isle of Pines, resulted in the accumulation of an extensive collection of girardinin fishes including many thousands of specimens representing all the known forms, some of which have been described as new by the present writer (Rivas, 1944*a*, 1944*b*). Part of the field work consisted in obtaining ecological and behavioral data and the bringing of live specimens to the laboratory, where they were kept under observation for long periods of time.

This wealth of material has permitted a thorough study of the tribe and it is believed that no undescribed species remain to be discovered. Once the systematics, ecology, behavior, and distribution of the species were fairly well known, it remained as a most challenging field of research, the study of the origin and phylogeny of the group, and the modes of speciation and dispersal of its members. The isolated position of the tribe Girardinini, both as to its relationships and distribution, presents interesting problems of origin and phylogeny which have puzzled students of West Indian ichthyology.

The purpose of the present work is to establish the phylogeny and relationships of the tribe and to trace its origin to a single common ancestor which is assumed to have migrated into western Cuba directly from Central America during the Miocene-Pliocene. The manner in which this migration took place is discussed and based on ecological, behavioral, and paleogeographical data. A study and discussion of speciation and dispersal is offered by correlating the biological data with the paleoecology and paleogeography of the island of Cuba. A theory expressing the author's views in connection with these matters is given in the following four postulates, whose development forms the main body of this study.

1.—The species comprised in the tribe Girardinini were derived from a single, common ancestor which migrated to the island of Cuba from Central America.

2.—The migration was effected through fresh water, by means of a land connection between eastern Yucatan—British Honduras and western Cuba.

3.—Speciation in the tribe Girardinini has occurred chiefly through adaptive radiation, and its center of origin was located in western Cuba.

* Contribution No. 32 from the Ichthyological Laboratory and Museum, Department of Zoology, University of Miami.

4.—The mechanisms of speciation and dispersal leading to the present forms within the tribe and their geographical distribution are explained by the paleogeography and paleoecology of the island of Cuba.

It is obvious that a study of the origin, speciation, and dispersal of a group of fresh-water fishes, especially on an isolated island, must take into consideration the present, as well as the past physiography and environmental conditions of the region, in addition to a knowledge of the biology of the group. It is the study and correlation of these factors that forms the basis upon which reasonable theories can be constructed. Although much work remains to be done, enough data on the physiography, geology, and paleogeography of Cuba are available for the purposes of the present study.

Fossil poeciliids are as yet unknown, but there is the possibility that some may be uncovered when regions where they are likely to occur are thoroughly explored. Careful investigation of "fossil stream beds" in western Cuba (Massip, 1942: 74), may disclose paleontological evidence which should be most useful in studies of phylogeny, evolution, and dispersal of girardinin and other Cuban fresh-water fishes. According to the evidence presented in the last part of this study (pp. 313–318), fossil girardinins should be looked for in Pleistocene alluvial deposits.

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Although the present work was first conceived and outlined at the Scripps Institution of Oceanography and Stanford University during the spring of 1947, it was actually conducted and brought to completion at the author's laboratory in the Department of Zoology, University of Miami, Florida.

[1] Now Chief, Gulf Fisheries Exploration and Gear Research, U. S. Fish and Wildlife Service.

## MATERIALS AND METHODS

The present study is based almost entirely on the author's collections of girardinin fishes (C.L.R.R.), totaling about 7,000 specimens representing all the known species. Additional specimens in the United States National Museum (U.S.N.M.), Stanford Natural History Museum, and Museum of Comparative Zoology have been examined.

The author's specimens were obtained by seining with fine-meshed nets under conditions insuring the capture of a fairly accurate cross-section of the population including those newly born. Temperatures were nearly always taken, and water and bottom samples were often taken back to the laboratory for analysis. Altitudes were measured with an aneroid altimeter. Ecological conditions such as turbidity, depth, nature of the bottom, current, vegetation, and predators, were studied in the field.

Behavior was mostly studied in the laboratory by observation of live material kept in aquaria, but whenever possible observations were made in the field by means of glass-bottom buckets or by swimming under water with a face mask. Food was investigated by direct observation in the field and laboratory, and by examination of stomach contents.

The taxonomic analysis is based on detailed study of representative series of specimens of each form from many localities and different ecological conditions throughout their respective ranges. Proportions and counts are self-explanatory.

## 1. THE SPECIES COMPRISED IN THE TRIBE GIRARDININI WERE DERIVED FROM A SINGLE, COMMON ANCESTOR WHICH MIGRATED TO THE ISLAND OF CUBA FROM CENTRAL AMERICA

### TAXONOMY OF THE TRIBE GIRARDININI

The genera and species of the exclusively Cuban tribe Girardinini form, within the family Poeciliidae,[2] a compact, natural group whose recogni-

[2] The Poeciliidae belong to the order Cyprinodontes and comprise some 48 genera and about 140 species of small, ovoviviparous fishes, most of which occur in fresh

tion emphasizes the sharp differentiation which it has undergone since it first became established on the island. The following genera, species, and subspecies are comprised in the tribe.

Tribe **Girardinini** Hubbs

Girardinini Hubbs, 1924: 9 (original diagnosis); 1926: 20 (relationships), 58 (relationships, Cuba). Howell-Rivero and Rivas, 1944: 6 (characters), 12–14 (general account).

Genus *Toxus* Eigenmann

*Toxus* Eigenmann, 1903: 226 (original description); *Toxus riddlei*). Hubbs, 1924: 9 (characters in key); 1926: 58 (comments). Howell-Rivero and Rivas, 1944: 9, 10 (characters in key).

*Toxus serripenis*, new species
Figs. 1 (5, 6); 11 (2)

Holotype, adult male 31 mm. in standard length, collected by Luis Rene Rivas in Rio Taco Taco at Rangel, Province of Pinar del Rio (C.L.R.R. No. 69). Paratypes: ten adult males, 27 to 35.5 mm., and twenty-two half grown to adult females, 32 to 60 mm. in standard length, all collected with the holotype. Diagnosis, comparisons and relationships are given in the analytical keys.

*Toxus creolus* (Garman)
Figs. 2 (1, 2); 11 (2)

*Girardinus creolus* Garman, 1895: 47 (original description, Cuba).
*Toxus riddlei* Eigenmann, 1903: 226 (original description, San Cristobal).
*Toxus creolus*, Howell-Rivero and Rivas, 1944: 17.

Genus *Glaridichthys* Garman

*Glaridodon* (not *Glaridodon* Seeley) Garman, 1895: 40 (original description; *Girardinus uninotatus*).
*Glaridichthys* Garman, 1896: 232 (substitute for *Glaridodon*, preoccupied). Hubbs, 1924: 9 (characters in key); 1926: 58 (genus confined to Cuba). Howell-Rivero and Rivas, 1944: 7 (characters in key).

*Glaridichthys uninotatus uninotatus* (Poey)
Figs. 2 (3, 4); 11 (2)

*Girardinus uninotatus* Poey, 1860: 309 (original description; Rio Taco Taco, Province of Pinar del Rio).
*Glaridichthys uninotatus*, Eigenmann, 1903. Hubbs, 1926: 59.

*Glaridichthys uninotatus torralbasi* Eigenmann
Figs. 2 (5, 6); 11 (2)

*Glaridichthys torralbasi* Eigenmann, 1903: 225 (original description; Rio del Pinar). Hubbs, 1926: 59.

*Glaridichthys falcatus* Eigenmann
Figs. 3 (1, 2); 11 (2)

*Glaridichthys falcatus* Eigenmann, 1903: 224 (original description; San Cristobal, Los Palacios, Rio del Pinar). Hubbs, 1926: 60.
*Glaridichthys atherinoides* Rivas, 1944*a*: 3 (original description; Arroyo Blanco, Province of Camaguey).

Genus *Allodontium* Howell-Rivero and Rivas

*Allodontium* Howell-Rivero and Rivas, 1944: 17 (original description; *Heterandria cubensis* Eigenmann).

*Allodontium cubense* (Eigenmann)
Figs. 3 (3, 4); 11 (2)

*Heterandria cubensis* Eigenmann, 1903: 227 (original description; Los Palacios; Pinar del Rio).
*Toxus cubensis*, Hubbs, 1926: 58.
*Allodontium cubense*, Howell-Rivero and Rivas, 1944: 12–18.

Genus *Dactylophallus* Howell-Rivero and Rivas

*Dactylophallus* Howell-Rivero and Rivas, 1944: 15 (original description; *Girardinus denticulatus* Garman).

*Dactylophallus denticulatus denticulatus* (Garman)
Figs. 3 (5, 6); 11 (2)

*Girardinus denticulatus* Garman, 1895: 47 (original description; Remedios, Cuba).
*Dactylophallus denticulatus*, Howell-Rivero and Rivas, 1944: 15–17.

*Dactylophallus denticulatus ramsdeni* Rivas
Figs. 4 (1, 2); 11 (2)

*Dactylophallus ramsdeni* Rivas, 1944*a*: 48 (original description; Rio Guaso, Guantanamo, Province of Oriente).

Genus *Girardinus* Poey

*Girardinus* Poey, 1854: 383 (original description; *Girardinus metallicus* Poey). Howell-Rivero and Rivas, 1944: 8–9 (characters in key).

water, although a few species are normally found in brackish or even salt water along swampy shores. This compact family is characterized by the structure of the anal fin of the males which is transformed into a copulatory organ (gonopodium) by elongation of rays 3, 4, and 5. The family is confined to the Western Hemisphere from the Delaware River southward to Rio de la Plata including the West Indies, on the Atlantic, and from the Colorado River southward to Ecuador, on the Pacific. The members of this family, commonly known as "Top minnows," are popular with aquarists who call them "Live-bearers." For detailed information on this family, see Regan (1913), Henn (1916), Hubbs (1924, 1926).

*Girardinus microdactylus* Rivas
Figs. 4 (3, 4); 11 (2)

*Girardinus microdactylus* Rivas, 1944*a*: 51 (original description; Rio Taco Taco, Jardin de Blain, Province of Pinar del Rio).

*Girardinus metallicus* Poey
Figs. 4 (5, 6); 11 (2)

*Girardinus metallicus* Poey, 1854: 387 (original description; Jardin Botanico, Province of Habana).

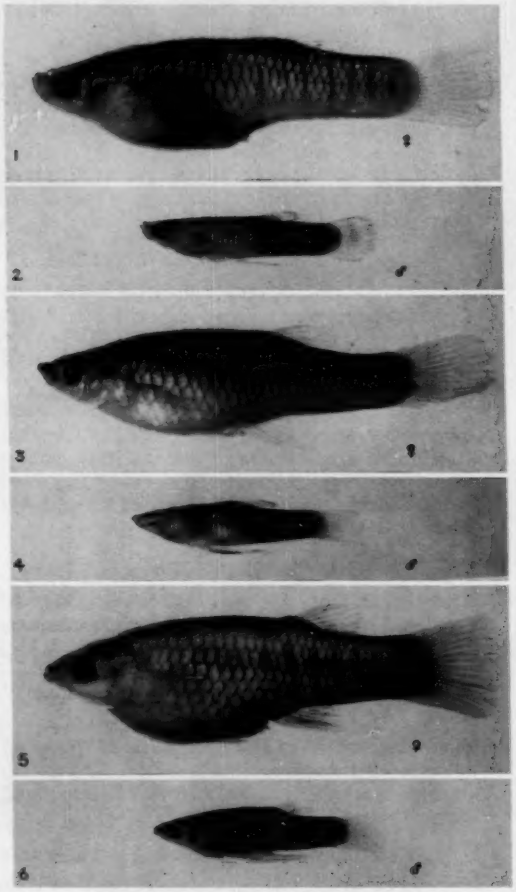

FIG. 1. (1, 2) *Allogambusia tridentiger*. Adult female and male, 28 and 17 mm. in standard length respectively, from Panama. (3, 4) *Phalloceros caudomaculatus*. Adult female and male, 44 and 29 mm. in standard length respectively, from Brazil. (5, 6) *Toxus serripenis*. Adult female paratype and male holotype, 52 and 31 mm. in standard length respectively, from Rio Taco Taco, Province of Pinar del Rio. (Photographs by the Smithsonian Institution.)

*Girardinus garmani* Eigenmann, 1903: 226 (original description; Pinar del Rio; Los Palacios).

*Girardinus pygmaeus* Rivas, 1944*a*: 49 (original description; Rio Hatiguanico, Province of Matanzas).

The first ichthyologist to point out the isolated position of this group taxonomically was Hubbs

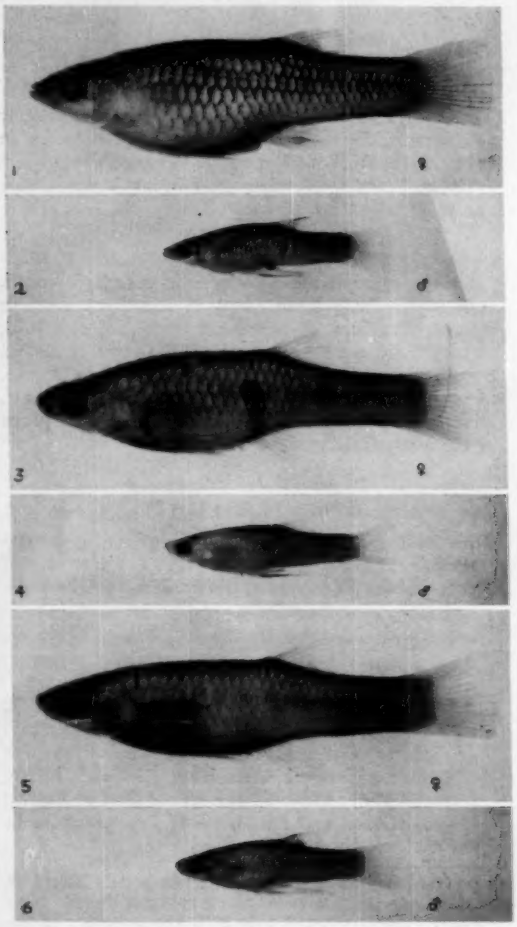

FIG. 2. (1, 2) *Toxus creolus*. Adult female and male, 46 and 28 mm. in standard length respectively, from Rio Sumidero, Province of Pinar del Rio. (3, 4) *Glaridichthys uninotatus uninotatus*. Adult female and male, 67 and 36.5 mm. in standard length respectively, from Rio Taco Taco, Province of Pinar del Rio. (5, 6) *Glaridichthys uninotatus torralbasi*. Adult female and male, 44 and 33 mm. in standard length respectively, from Rio Guama, Province of Pinar del Rio. (Photographs by the Smithsonian Institution.)

(1924: 9). On the basis of gonopodial characters, he diagnosed the tribe as follows: "Ray 3 with a pair of curved horn-like appendages near tip; ray 5 with the posterior edge serrate." Later (1926: 50), he reaffirmed his conclusions and pointed out that the tribe was confined to Cuba, thus correlating taxonomic status with geographical distribution. Howell-Rivero and Rivas (1944) have recently confirmed these conclusions and presented a detailed taxonomic study of the tribe including descriptions of two new additional genera (*Dactylophallus, Allodontium*).

My recent studies have further emphasized the integrity of the tribe Girardinini. In their fundamental features, the genera and species are in complete agreement. Their adaptive radiation

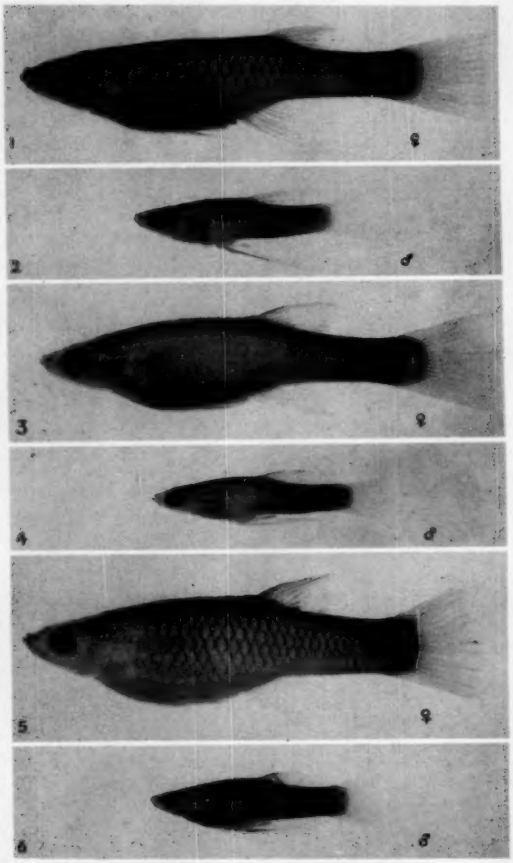

FIG. 3. (1, 2) *Glaridichys falcatus*. Adult female and male, 55 and 28 mm. in standard length respectively, from Rio Cayojo, Province of Oriente. (3, 4) *Allodontium cubense*. Adult female 41 mm. in standard length, from Laguna de Piedras, Province of Pinar del Rio, and adult male 24.5 mm. in standard length, from Rio Guama, Province of Pinar del Rio. (5, 6) *Dactylophallus denticulatus denticulatus*. Adult female and male, 59 and 38 mm. in standard length respectively, from Rio Rancho Nuevo, Province of Oriente. (Photographs by the Smithsonian Institution.)

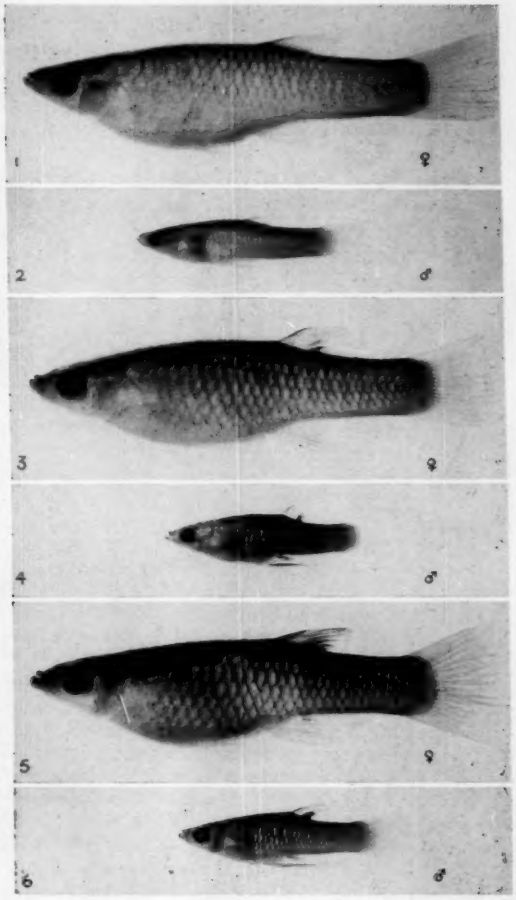

FIG. 4. (1, 2) *Dactylophallus denticulatus ramsdeni*. Adult female and male, 44 and 27 mm. in standard length respectively, from Rio Guaso, Province of Oriente. (3, 4) *Girardinus microdactylus*. Adult female and male, 50 and 29 mm. in standard length respectively, from Rio Taco Taco, Province of Pinar del Rio. (5, 6) *Girardinus metallicus*. Adult female and male, 50 and 28 mm. in standard length, from Rio Punta Brava, Province of Habana. (Photographs by the Smithsonian Institution.)

seems to have been related chiefly to feeding habits, since most of the generic characters involve the structure of the jaws, lips, and teeth. There is every reason to believe that the tribe has evolved in Cuba, after a single ancestral species migrated into what is now that island.

Careful and detailed studies of the extensive material at hand have permitted an interpretation of relationships among the members of the tribe. In order to present as true a picture as possible of these relationships, as a basis to construction of the phylogeny of the group, the following procedure will be followed. A separate natural taxonomic analysis of the tribe, based exclusively on gonopodial characters (figs. 5 (6); 7, C) will be presented first followed by a separate, natural analysis based on adult, non-gonopodial characters, and a third analysis based on juvenile characters.

The following diagnosis comprises the characters common to all the members of the tribe.

### DIAGNOSIS OF THE TRIBE GIRARDININI

Ray 3 of gonopodium (figs. 5 (6); 7, C) edged anteriorly, smooth, rather abruptly constricted distally, with a pair of subterminal, membranous finger-like appendages hooked distally; the last segment divided, and forming laterally diverging halves; ray pigmented axially with melanophores, the pigmentation decreasing distally in area and intensity. Segments of ray 3, at base of appendages, modified as a supporting structure for the appendages. Anterior branch of ray 4 much thicker than posterior branch; both branches separated distally, and their tips slightly bent towards ray 3. Tip of anterior branch of ray 4 in contact with tip of ray 3. Posterior branch of ray 4 constricted distally, with several retrorse pairs of serrae per serrae-bearing segment (without serrae in *Toxus creolus*). Subterminal segments of anterior branch of ray 5, more or less enlarged, the distal end of the branch more or less club-shaped. Several (5 to 16) subterminal segments of posterior branch of ray 5, each modified into a pair of strong retrorse serrae. Gonopodium relatively long, more than 40 per cent of the length of the body without caudal, reaching beyond vertical from posteriormost point of dorsal fin. Gonopodial suspensorium [3] composed of three gonapophyses (modified anterior haemal spines) all impinging against the interhaemals; the first not forming a terminal ring; each with a strong uncinatoid process; no parapophyses on gonapophyses. Compound interhaemal formed of 2nd, 3rd, and 4th interhaemals, with a strong, bilobed lateral keel; posterior interhaemals rod-like and well separated. Gape of mouth more transverse than lateral. Teeth of outer row compressed, curved inward, expanded subapically. Teeth of inner row minute, conical, sharply pointed. Preorbital sensory organ an open groove in juveniles, a closed tube with pores in the adult. Origin of dorsal fin behind origin of anal in both sexes. Dorsal rays 8 or 9; anal rays 9 or 10. Scales in 28 to 31, usually 29 or 30 transverse rows. Vertebrae 29 to 31, usually 30. Gill rakers developed, short, not close set, 17 to 21, usually 18 to 20 on outer arch. Scale pockets margined with dusky, the resulting reticulate pattern undeveloped on the ventral part of the body, especially the belly. A black line running along the lower edge of the caudal peduncle. Sides of body with several, more or less distinct dusky crossbars more conspicuous in males and young females. Standard length about 8 mm. at birth, attaining maturity at about 20 mm.; adult males always less than 50 mm. in standard length, and females 90 mm. Species limnophagous or phytophagous, occurring in midwater or on the bottom, rarely in the upper stratum or at the surface. Fresh waters of the island of Cuba and the Isle of Pines; not known to stray into brackish or salt water.

[3] Skeletal apparatus connecting the vertebral column with the gonopodium and serving as a support for the latter. It is composed of the modified, anterior 2 or 3 haemal spines and the modified, anterior interhaemal spines. For detailed explanation of this structure and the gonopodium itself, see Howell-Rivero, 1946 and Howell-Rivero and Rivas, 1944.

### NATURAL ANALYSIS OF THE TRIBE GIRARDININI BASED ON GONOPODIAL CHARACTERS

*1a.*—Ray 3 not bent inward near tip, at base of appendages. Distal segments of ray 3 and anterior branch of ray 4, gradually increasing in length from the short apical segments to the comparatively long middle segments. Posterior branch of ray 4 smooth or with up to 7 pairs of comparatively large, retrorse serrae. Subterminal segments of anterior branch of ray 5 broadly enlarged transversely, forming an elbow-like swelling; tip of branch not reaching to base of appendages. Posterior branch of ray 5 with 12 to 16 pairs of retrorse serrae, its tip not reaching to base of appendages. Gonopodium shorter, 2.3 to 2.8 in standard length. (*Toxus.*)

*2a.*—Posterior branch of ray 4 with 2 to 7 pairs of strong, retrorse serrae. Distalmost segments of anterior branch of ray 5 (above elbow) comparatively large, usually partly fused, 2 or 3 in number; elbow-like swelling of branch broader and less elongate.

*Toxus serripenis.*

*2b.*—Posterior branch of ray 4 without serrae. Distalmost segments of anterior branch of ray 5 comparatively small, usually not fused, 4 to 6 in

number; elbow-like swelling of branch less broad and more elongate.

*Toxus creolus.*

*1b.*—Ray 3 bent inward near tip, at base of appendages. Distal segments of ray 3 and anterior branch of ray 4, abruptly increasing in length from the short, apical segments to the much longer middle segments. Posterior branch of ray 4 always with more than 7 pairs of comparatively small retrorse serrae. Subterminal segments of anterior branch of ray 5 somewhat enlarged transversely, forming an incipient elbow-like swelling; tip of branch reaching beyond base of appendages. Posterior branch of ray 5 with 5 to 12 pairs of retrorse serrae, its tip reaching beyond base of appendages. Gonopodium longer, 1.9 to 2.3 in standard length. (*Glaridichthys, Allodontium, Dactylophallus, Girardinus.*)

*3a.*—Anterior branch of ray 5 reaching to, or somewhat beyond point midway between base of appendages and tip of ray 3. Serrae on posterior branch of ray 5 ending abruptly distally, without a decrease in size. (*Glaridichthys.*)

*4a.*—Posterior branch of ray 5 with its 4 to 6 terminal segments unarmed with serrae. Length of gonopodium, 2.2 or 2.3 in standard length.

*Glaridichthys uninotatus.*

*4b.*—Posterior branch of ray 5 with its 2 to 4 terminal segments unarmed with serrae. Length of gonopodium, 2.0 or 2.1 in standard length.

*Glaridichthys falcatus.*

*3b.*—Anterior branch of ray 5 not quite reaching to point midway between base of appendages and tip of ray 3. Serrae on posterior branch of ray 5 gradually decreasing in size distally. (*Allodontium, Dactylophallus, Girardinus.*)

*5a.*—Posterior branch of ray 5 with its 2 terminal segments unarmed with serrae (*Allodontium, Dactylophallus.*)

*6a.*—Posterior branch of ray 5 with 6 to 8 pairs of serrae.

*Allodontium cubense.*

*6b.*—Posterior branch of ray 5 with 7 to 12 pairs of serrae.

*Dactylophallus denticulatus.*

*5b.*—Posterior branch of ray 5 with its 3 or 4 terminal segments unarmed with serrae. (*Girardinus.*)

*7a.*—Finger-like appendages on ray 3 comparatively slender, not reaching to tip of ray. Ray 3 more or less slightly bent inward at base of appendages. Laterally diverging halves of divided terminal segment or ray 3, each forming a well developed retrorse branch. Transversely enlarged subterminal segments of anterior branch of ray 5, about equal in size to subterminal segments of posterior branch of ray 4.

*Girardinus microdactylus.*

*7b.*—Finger-like appendages on ray 3 comparatively stout, reaching to, or beyond tip of ray. Ray 3 markedly bent inward at base of appendages. Laterally diverging halves of divided terminal segment of ray 3 not developed into retrorse branches. Transversely enlarged subterminal segments of anterior branch of ray 5, much larger than subterminal segments of posterior branch of ray 4.

*Girardinus metallicus.*

## NATURAL ANALYSIS OF THE TRIBE GIRARDININI BASED ON ADULT NON-GONOPODIAL CHARACTERS

*1a.*—Gape of mouth below transverse axis passing through center of eyes, in front and side views. Teeth of outer row comparatively large, more widely spaced and fewer. Preorbital sensory tube not concentric with orbit, forming a broad, reversed L with one slightly curved arm near front of bone concentric with orbit, and the other along lower border ending in a pore close to orbit. Body more robust. Dorsal and anal fins evenly rounded, without sharp angles, not subtriangular in shape. Caudal fin evenly rounded especially in males, without sharp angles, its posterior margin strongly convex. Pectoral fin large, broadly rounded, with 14 or 15 rays. Origin of dorsal fin nearer caudal base than insertion of pectoral fin. Predorsal contour strongly convex, especially between tip of snout and occiput; not at all flattened transversely. Pigmentation strongly developed. (*Toxus.*)

*2a.*—Dorsal rays 8. Eye smaller, 3.2 to 3.6 in head in males; 3.8 to 4.3 in females. Upper reaches of Rio Taco Taco, above the falls (fig. 11 (2)).

*Toxus serripenis.*

*2b.*—Dorsal rays 9. Eye larger, 2.9 to 3.2 in head in males; 3.3 to 3.7 in females. Highland streams of the southern drainage of Sierra de los Organos (fig. 11 (2)).

*Toxus creolus.*

*1b.*—Gape of mouth above transverse axis passing through center of eyes, in front and side views. Teeth of outer row comparatively small, less widely spaced and more numerous. Preorbital sensory tube concentric with orbit, not L-shaped, slightly curved, in front of middle of bone, its lower pore far removed from orbit. Body less robust. Dorsal and anal fins not evenly rounded, with more or less sharp angles, subtriangular in

shape. Caudal fin not evenly rounded, with more or less sharp angles, its posterior margin somewhat concave, straight or slightly convex. Pectoral fin small, elongate, with 11 to 13 rays. Origin of dorsal fin midway between middle of caudal base and insertion of pectoral fin or posterior border of opercle. Predorsal contour straight, sigmoid or slightly convex; never strongly convex between tip of snout and occiput; more or less flattened transversely. Pigmentation not strongly developed. (*Glaridichthys, Allodontium, Dactylophallus, Girardinus.*)

*3a.*—Jaws strong and firmly united. Upper lip entirely visible in front view. Teeth of outer row broadly expanded subapically, chisel-shaped, firmly and close set in jaws, in contact and partly overlapping on another thus forming a rather even cutting edge; regularly arranged in a moderate, even arc on each jaw. Gape of mouth markedly arched in front view. (*Glaridichthys.*)

*4a.*—Caudal peduncle deeper, its least depth 6.2 to 7.0 in standard length. Origin of dorsal fin above middle of anal base or somewhat behind in females; nearer tip of snout than tip of middle caudal rays in females. Anal fin scarcely or not at all falcate in females, the third ray shorter than distance between origins of dorsal and anal fins. Pigmentation well developed. Sides of body with metallic reflections but not forming a definite, narrow, bright silvery or golden longitudinal band in life. Flesh opaque or little translucent, in life, the vertebral column and internal organs not visible. Highland streams of the southern and northwestern drainage of Sierra de los Organos (fig. 11 (*2*)).

*Glaridichthys uninotatus.*

*5a.*—Posterior margin of caudal fin usually somewhat concave, sometimes straight. Posterior margin of anal fin usually concave in females. Sides of body with a conspicuous, black blotch about the size of the eye, in the middle above anus; the blotch sometimes connected by a black streak with the blackened peritroct. Dorsal fin somewhat dusky basally, the pigmentation not forming a definite cross band. Rio Guamá system eastward.

*Glaridichthys uninotatus uninotatus.*

*5b.*—Posterior margin of caudal fin usually convex. Posterior margin of anal fin usually convex in females. Sides of body usually without a black blotch. Dorsal fin with a subbasal dusky cross band, more conspicuous in males. Rio Guamá system westward.

*Glaridichthys uninotatus torralbasi.*

*4b.*—Caudal peduncle more slender, its least depth, 7.1 to 8.5 in standard length. Origin of dorsal fin above end of anal base in females; about midway between tip of snout and tip of middle caudal rays or nearer tip of middle caudal rays in females. Anal fin falcate in females, the third ray longer than distance between origins of dorsal and anal fins. Pigmentation weakly developed. Sides of body with a narrow, bright, well defined silvery or golden longitudinal band in life. Flesh translucent in life, the vertebral column and internal organs visible. Ponds, lakes and lowland streams of central and western Cuba (fig. 11 (*2*)).

*Glaridichthys falcatus.*

*3b.*—Jaws weak and loosely united. Upper lip not entirely visible in front view. Teeth of outer row less broadly expanded subapically, cutlass-, knife-, or spear-shaped, not firmly set in jaws, more or less widely spaced, not forming a cutting edge and arranged in two weak or strong arcs meeting at symphysis on lower jaw. Gape of mouth straight or weakly arched in front view. (*Allodontium, Dactylophallus, Girardinus.*)

*6a.*—Gape of mouth nearly horizontal in side view; weakly arched but not straight, in front view. Jaws less weak and less loosely united. Lower jaw not strongly projecting beyond upper, the lower lip scarcely visible from above. Upper lip uniformly convex, not forming a concave depression at symphysis, about half visible in front view. Lower lip convex, not notched at symphysis in dorsal view. Lip papillae undeveloped. Teeth of outer row symmetrically expanded subapically, spear-shaped, sharply pointed, not curved away from symphysis, strictly uniserial, not displaced in alternating pattern and arranged in a very weak arc on the upper jaw and two very weak arcs meeting at symphysis, on the lower jaw. Branched caudal rays 12. Origin of dorsal fin in advance of middle of anal base in females. Longest dorsal ray longer than distance between origins of dorsal and anal fins in females. Caudal peduncle slender, its least depth 3.0 or 3.1 in its length. Dorsal and anal fins without a black spot or a subbasal dusky cross band. Ponds, lakes, and streams of the southern drainage of Sierra de los Organos, Province of Pinar del Rio (fig. 11 (*2*)). (*Allodontium.*)

*Allodontium cubense.*

*6b.*—Gape of mouth oblique or nearly vertical in side view; straight in front view. Jaws weaker and more loosely united. Lower jaw strongly projecting beyond upper, the

lower lip widely visible from above. Upper lip forming a concave depression at symphysis, scarcely visible in front view. Lower lip straight, concave or notched at symphysis in dorsal view. Lip papillae developed. Teeth of outer row asymmetrically expanded subapically, cutlass- or knife-shaped, not sharply pointed, curved away from symphysis, not strictly uniserial, displaced in alternating pattern and sometimes appearing to form 2 or 3 rows arranged in two arcs meeting at symphysis, on each jaw. Branched caudal rays 13 to 15. Origin of dorsal fin above middle of anal base in females. Longest dorsal ray shorter than distance between origins of dorsal and anal fins in females. Caudal peduncle more robust, its least depth, 2.4 to 2.8 in its length. Dorsal fin of males and young females with a black spot or a subbasal dusky, cross band. (*Dactylophallus, Girardinus.*)

*7a.*—Gape of mouth oblique, not nearly vertical in side view. Jaws less weak and less loosely united. Lower lip straight or concave, but not notched at symphysis in dorsal view. Lip papillae undeveloped towards rictus. Lower border of preorbital slightly raised but not free. Preorbital typically scaleless. Inner row of teeth present. Arcs formed by teeth of outer row, less curved; the teeth continuous at symphysis on both jaws. Dorsal and anal fins slightly falcate in females, about equal in size or the dorsal larger than the anal in females. Dorsal fin of males and young females with a subbasal, dusky cross band. Sides of body with a broad, silvery or golden longitudinal band in life, not broken up into definite cross bars. Ponds, lakes and streams of central and eastern Cuba (fig. 11 (2)).

*Dactylophallus denticulatus.*

*8a.*—Mouth larger, its overall width, 2.9 to 3.1 in head in males; 2.5 to 2.9 in females. Lip papillae well developed. Caudal peduncle more slender, its least depth, usually more than 6.9 in standard length in females. Central and eastern Cuba, except Rio Guaso and Yateras systems.

*Dactylophallus denticulatus denticulatus.*

*8b.*—Mouth smaller, its overall width 3.0 to 3.2 in head in males; 2.9 to 3.3 in females. Lip papillae scarcely developed or obsolete. Caudal peduncle more robust, its least depth, usually less than 6.9 in standard length in females. Rio Guaso and Rio Yateras systems, southeastern drainage of Sierra Maestra, Province of Oriente, eastern Cuba.

*Dactylophallus denticulatus ramsdeni.*

*7b.*—Gape of mouth vertical or nearly so in side view. Jaws weaker and more loosely united. Lower lip usually notched at symphysis in dorsal view. Lip papillae well developed towards rictus. Lower border of preorbital free. Preorbital typically with a few scales. Inner row of teeth obsolete. Arcs formed by teeth of outer row more curved, the teeth interrupted at symphysis by a narrow, edentulous midsection on each jaw. Dorsal and anal fins not falcate in females. Dorsal fin smaller than the anal in females. Dorsal fin of males and females with a basal, more or less diffuse black spot. Sides of body with about 8, equally spaced, silvery or golden cross bars in life. (*Girardinus*).

*9a.*—Scales in 30 or 31 transverse rows. Teeth of outer row more broadly expanded subapically. Black spot on dorsal fin not well defined; diffuse or transformed into a dusky, median cross band, especially in large females. Anal fin usually with a diffuse, black spot or a diffuse, dusky cross band. Highland streams of the southern drainage of Sierra de los Organos and the Isle of Pines (fig. 11 (2)).

*Girardinus microdactylus.*

*9b.*—Scales in 28 or 29 transverse rows. Teeth of outer row less broadly expanded subapically. Black spot on dorsal fin well defined, not diffuse or transformed into a median, cross band. Anal fin without black in females. Ponds, lakes and streams throughout the island, except the easternmost portion (fig. 11 (2)).

*Girardinus metallicus.*

NATURAL ANALYSIS OF THE TRIBE GIRARDININI BASED ON JUVENILE CHARACTERS

*1a.*—Pectoral rays 14 or 15 (*Toxus*).

*2a.*—Dorsal rays 8.

*Toxus serripenis.*

*2b.*—Dorsal rays 9.

*Toxus creolus.*

*1b.*—Pectoral rays 11 to 13. (*Glaridichthys, allodontium, Dactylophallus, Girardinus.*)

*3a.*—Teeth of outer row broadly expanded subapically, chisel-shaped, in contact and partly overlapping one another forming a rather even cutting edge. Gape of mouth markedly arched in front view. (*Glaridichthys.*)

*4a.*—Origin of dorsal fin above middle of anal base or somewhat behind. Sides of body with a black spot in the middle, above anus.

*Glaridichthys uninotatus.*

*4b.*—Origin of dorsal fin above end of anal base. Sides of body without a black spot.

*Glaridichthys falcatus.*

*3b.*—Teeth of outer row less broadly expanded subapically, cutlass-, knife,- or spear-shaped, more or less widely spaced, not forming a cutting edge. Gape of mouth straight or weakly arched in front view. (*Allodontium, Dactylophallus, Girardinus.*)

*5a.*—Teeth of outer row symmetrically expanded subapically, spear-shaped, sharply pointed, not curved away from symphysis, strictly uniserial, not displaced in alternating pattern. Origin of dorsal fin in advance of middle of anal base. (*Allodontium.*) (*Allodontium cubense.*)

*5b.*—Teeth of outer row asymmetrically expanded subapically, cutlass- or knife-shaped, not sharply pointed, curved away from symphysis, not strictly uniserial and displaced in alternating pattern. Origin of dorsal fin above middle of anal base. (*Dactylophallus, Girardinus.*)

*6a.*—Dorsal and anal fins without spots or bands. (*Dactylophallus.*) (*Dactylophallus denticulatus.*)

*6b.*—Dorsal and anal fins with a black, basal spot sometimes extended into a dusky, cross band on anal fin. (*Girardinus.*)

*7a.*—Scales in 30 or 31 transverse rows. *Girardinus microdactylus.*

*7b.*—Scales in 28 or 29 transverse rows. *Girardinus metallicus.*

## PHYLOGENY

The above diagnosis and analyses emphasize the compactness of the tribe Girardinini and indicate that differentiation among its members has proceeded mainly along gonopodial and mouth characters, especially the latter. It is also evident that indicated relationships remain the same, regardless of the method of analysis.

As to the value of the characters in interpreting phylogeny, those of the gonopodium are perhaps more significant since they do not seem to be correlated with ecological conditions and therefore may be considered as not directly adaptive. Differentiation along gonopodial characters is, in my opinion, indicative of isolation rather than adaptation to dissimilar ecological conditions. The taxonomic analyses indicate correlation between gonopodial and feeding characters, but this is to be expected since according to our present knowledge, speciation through ecological adaptation cannot be fully accomplished without the isolation factor. It is also significant that gonopodial differentiation does not proceed below the species level.

A study of the developmental stages of the gonopodium in the tribe Girardinini (fig. 5) reveals that the first character to appear is the distal constriction and general shape of ray 3. This is followed by the formation of the serrae on posterior branch of ray 4 (Heterandrini stage), except in *Toxus creolus.* Then the serrae on the posterior branch of ray 5 begin to form, followed by the appearance of an unpaired subterminal appendage on ray 3 (*Allogambusia* stage) which later develops into the diagnostic pair of finger-like appendages, as the final stage of development. Modification of the subterminal segments of ray 3 into supporting structures occurs before appearance of the subterminal appendage, and transformation of the terminal segment takes place simultaneously with the development of the finger-like appendages. During the early stages of development, the distal segments of ray 3 and anterior branch of ray 4 do not abruptly increase in length towards the middle of the branch. This primitive condition is retained in *Toxus* after full development of the gonopodium.

Of the twelve gonopodial features found to show differentiation within the tribe, nine sharply separate the genus *Toxus* from the other members of the group. These nine features appear to be more fundamental structurally than those separating the other genera and species among themselves. On the basis of gonopodial characters, it is obvious that the genera *Glaridichthys, Allodontium, Dactylophallus,* and *Girardinus,* are much more closely related among themselves than with *Toxus.* This strongly suggests two well defined primary phyletic lines represented by *Toxus* and by the other members of the tribe (fig. 6), and long isolation between the ancestors of these lines during an early period of the history of the group. The gonopodium of *Toxus* seems to be much more primitive, and it is therefore reasonable to assume that, on the basis of gonopodial characters, this genus is much closer to the common ancestor of the tribe than any of the others.

The presence of strong retrorse serrae on the posterior branch of ray 4 in *Toxus serripenis* and their absence in *T. creolus,* is difficult to explain. The relationships of the tribe Girardinini (see p. 294) which are traced to Central (*Allogambusia*) and South America (*Phalloceros*), indicate that this character was already in the gonopodium of the ancestor of the tribe when it arrived in Cuba. On the basis of this character, *Toxus serripenis* would seem to be more closely related to the other members of the tribe, than *T. creolus.*

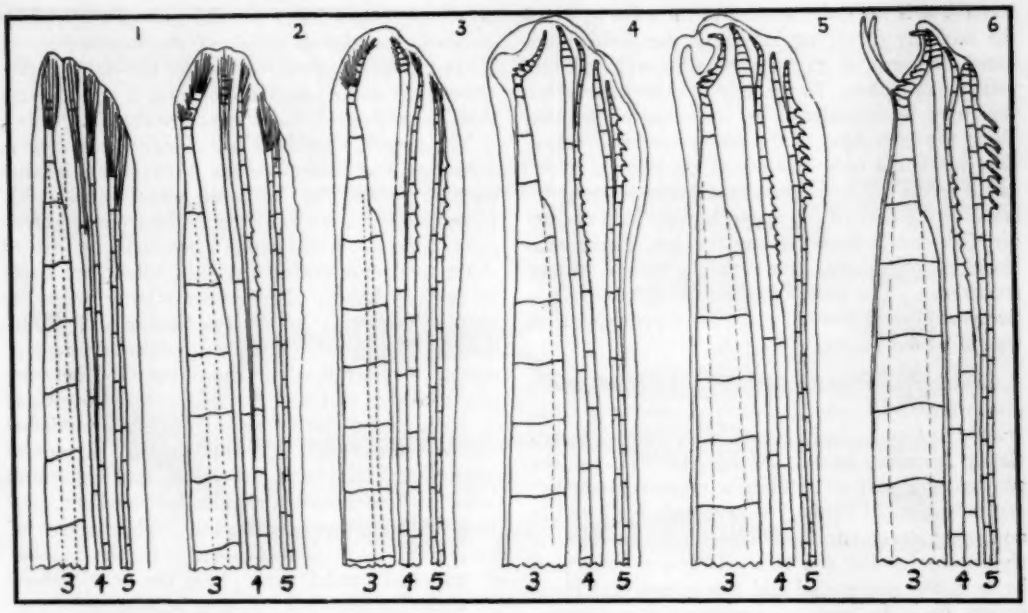


FIG. 5. Developmental stages of the gonopodium of a typical girardinin fish (*Glaridichthys uninotatus*). (1) Distal constriction of ray 3 begins to form. Rays 4 and 5 remain unmodified. (2) Distal constriction of ray 3 is completed. Tip of ray 3 begins to bend inwards. Serrae begin to form on posterior branch of ray 4 (Heterandrini stage). (3) Tips of branches of ray 4 become arched. Serrae begin to form on posterior branch of ray 5. (4) Subterminal segments of ray 3 become modified into supporting structures. Subterminal segments of anterior branch of ray 5 become enlarged. (5) Subterminal appendage on ray 3 is formed, but remains undivided (*Allogambusia* stage). (6) Gonopodium fully developed.

On the other hand, the structure of the elbow-like swelling of posterior branch of ray 4 in *T. creolus*, seems to indicate closer relationship with the other members of the tribe than *T. serripenis*. Which, if any, of these characters is more indicative of relationship, is difficult to decide. It seems certain however, that the serrae on posterior branch of ray 4, were lost in *Toxus creolus* after its ancestor was established and isolated in Cuba, and the species had acquired its tribal and generic characters.

The representatives of the less primitive phyletic line may be arranged on the basis of less fundamental gonopodial characters into two secondary groups: one including *Glaridichthys*, and the other *Allodontium*, *Dactylophallus*, and *Girardinus* (fig. 6). This suggests splitting of the population ancestral to these genera into two, after it became fully differentiated from the population ancestral to *Toxus*. These two populations must have been ecologically or geographically isolated for quite some time, as will be shown later.

Owing to the nature of the structures involved, it is difficult to determine whether the gonopodium of *Glaridichthys* is more primitive than that of *Allodontium*, *Dactylophallus*, or *Girardinus*. The gonopodia of *Glaridichthys uninotatus* and *G. falcatus* are essentially similar, although that of *G. falcatus* seems to be somewhat more primitive. *Glaridichthys* is more closely related to *Allodontium* than to *Dactylophallus* and *Girardinus*. The analysis shows that, on the basis of gonopodial characters, *Allodontium* and *Dactylophallus* seem to be very closely related and to form a natural group distinguished from *Girardinus*. This very close relationship indicated by the gonopodium is not apparent on the basis of other characters which in this case would seem to carry more weight. Actually, *Dactylophallus* is much more closely related to *Girardinus* than to *Allodontium*.

Although essentially similar, the gonopodia of *Girardinus microdactylus* and *G. metallicus* differ markedly in certain qualitative characters suggesting long isolation as the causal factor. *Girardinus*

*metallicus* is the only member of the tribe in which the laterally diverging halves of the divided terminal segment of ray 3 are not developed into retrorse branches. In the light of other characters, this may be considered as an advanced feature. With the exception of *Toxus*, *Girardinus microdactylus* is the only member of the tribe in which ray 3 of the gonopodium is not markedly bent inward at the base of the appendages. This character does not indicate, in my opinion, direct relationship with *Toxus*, but rather a case of genetic recurrence. The gonopodium of *Girardinus microdactylus* however, seems to be more primitive than that of *G. metallicus*.

Characters other than those of the gonopodium are in contrast markedly adaptive, especially those related to feeding and upon which generic differentiation is mainly based. As already indicated, the phylogenetic pattern of the tribe remains unaltered, regardless of the method of approach employed in analyzing divergence and relationships. This is significant in that the relationships, as indicated by both the gonopodial and non-gonopodial characters, must be true, as well as the taxonomic criteria for genera and species. Differentiation along feeding character is obviously indicative of adaptation to dissimilar environmental conditions. A detailed study of correlation between morphology, behavior, and ecology is offered under postulate no. 3 (p. 305).

An examination of the taxonomic analyses shows that the genus *Toxus* is again well distinguished by a series of characters relating to the mouth, body, and fins. In *Toxus*, the structure of the jaws, lips, and teeth is intermediate in relation to the other members of the tribe. The position of the mouth and preorbital sensory tube may be correlated with the structure of the head which is very convex dorsally, in conformity with that of the body whose axis is more straight than in any other member of the group. The general structure of the body, including the head, is well correlated with the habitat of the genus (rapid flowing highland streams). The rounded fins of *Toxus* are definitely primitive and unspecialized, although the larger pectorals seem to be correlated with swimming habits. The genus *Toxus* may then be considered as a generalized, relict group, much more primitive and closer to the ancestral species than any other member of the tribe. Good proof of the generalized nature of *Toxus* is that it cannot be shown to be more or less related to any of the other genera. On the basis of characters other than those of the gonopodium, it is difficult to establish which of the two species of *Toxus* is more primitive, but, in the light of distributional and ecological evidence, it would seem that *T. serripenis* is more primitive than *T. creolus*.

The genera *Glaridichthys*, *Allodontium*, *Dactylophallus*, and *Girardinus* are distinguished almost exclusively on the basis of mouth characters. *Glaridichthys* is well differentiated from *Allodontium*, *Dactylophallus*, and *Girardinus* by mouth characters representing a definite, divergent trend in feeding habits, sharply contrasting with the trend represented by *Dactylophallus* and *Girardinus*. The mouth structure of *Allodontium* represents a generalized, intermediate type between *Glaridichthys* and the *Dactylophallus-Girardinus* complex, more closely related to *Dactylophallus* and *Girardinus* than to *Glaridichthys*. In general proportions, body and fin shape, and coloration pattern, *Allodontium* is also an intermediate, generalized type showing a slightly higher degree of relationship with *Glaridichthys*. In the number of branched caudal rays (12), the relationships are with *Glaridichthys*. It may be assumed therefore, that *Allodontium* is an intermediate generalized form, more primitive than *Glaridichthys*, *Dactylophallus*, and *Girardinus*, and closer to their common ancestor.

*Glaridichthys falcatus* is more closely related to *Allodontium* than *Glaridichthys uninotatus* and therefore more primitive than the latter. The morphology, ontogeny, behavior, and ecology of these species suggest that *Glaridichthys uninotatus* was evolved through transformation of a species close to *G. falcatus*, chiefly through environmental pressure.

*Dactylophallus* is more primitive and closer to *Allodontium* than *Girardinus*. *Dactylophallus* and *Girardinus* are closely related, and ontogenetic studies suggest that either *Girardinus* was derived from *Dactylophallus* or, more likely, that the latter is much closer to their common ancestor than *Girardinus*.

*Glaridichthys uninotatus* and *Girardinus metallicus* may be considered as the present end points of two phyletic lines, each representing a diverging, adaptive speciational trend, and derived through *Allodontium* from the less advanced, primary phyletic line represented by *Toxus*. *Girardinus metallicus* is the most advanced and specialized member of the tribe Girardinini and *Toxus serripenis* the most primitive. A pictorial phylogeny of tribe Girardinini is given in fig. 6.

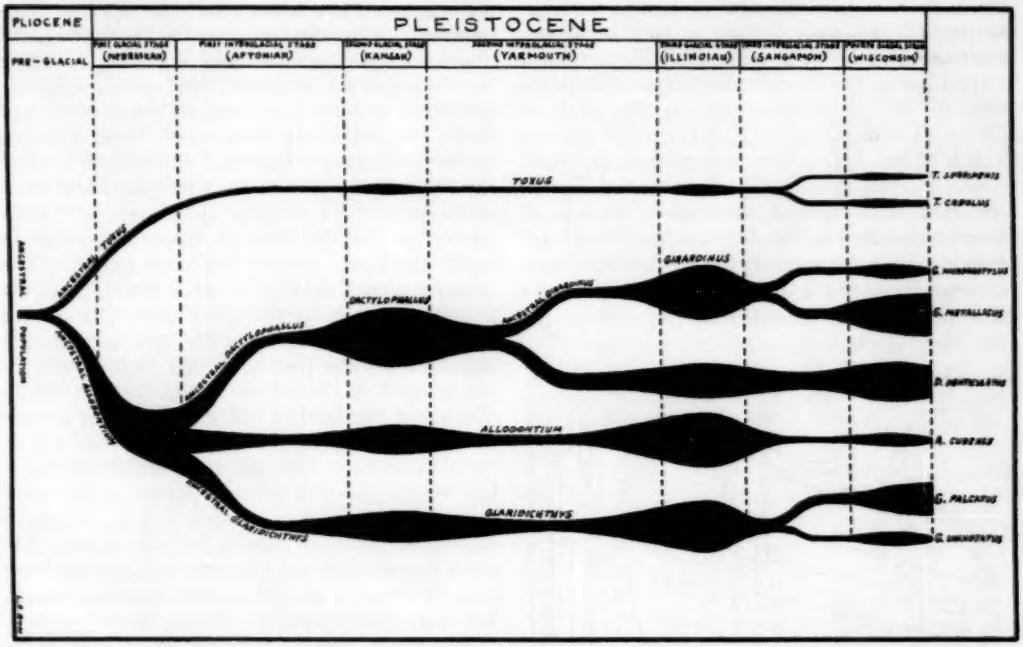


FIG. 6. Phylogeny of the tribe Girardinini. (See also fig. 13.) The width of the phyletic lines is proportional to the assumed size of the population at the given period. See text for further explanation.

## RELATIONSHIPS

Comparison of the tribe Girardinini with all the other members of the subfamily Gambusiinae (see Hubbs, 1924: 7–11) shows that its relationships are much closer to the monotypic genera *Allogambusia* (*tridentiger*, Garman, 1895: 89) and *Phalloceros* (*caudomaculatus*, Hensel, 1868: 362), of the tribes Heterandrini and Cnesterodontini respectively, than to any other member of the subfamily. *Allogambusia tridentiger* occurs in Central America and its range comprises both slopes of Panama. *Phalloceros caudomaculatus* occurs in southeastern South America, and its known range comprises southern Paraguay, northeastern Argentina, and southern Brazil and Uruguay, from Rio de Janeiro to the La Plata River.

Hubbs (1926: 58) stated that the tribe Girardinini is an offshoot from the Heterandrini, and that (*loc. cit.*: 56) *Allogambusia*, "In the development of the process of ray 3 . . . resembles the Girardinini." He was uncertain, however, as to whether or not this character is indicative of actual relationship. The relationships between the tribes Girardinini and Cnesterodontini have never been pointed out or discussed, although *Phalloceros caudomaculatus* was originally described under *Girardinus* and later also included under *Glaridichthys* by various authors without comment. Eigenmann (1907) correctly removed *caudomaculatus* from *Girardinus*, made it the type of *Phalloceros* and compared it with *Toxus*, *Glaridichthys*, and *Girardinus*, but without comment. Henn (1916: 124) compared *Phalloceros* with *Glaridichthys* and *Girardinus*, but offered no comment as to their relationships. Hubbs (1924: 7–11) correctly included *Phalloceros* and allied genera in a distinct, separate group (tribe Cnesterodontini). The evidence presented in this study shows that both the tribes Girardinini and Cnesterodontini are offshoots from the tribe Heterandrini.

A detailed comparative study (fig. 7) of the gonopodia of *Allogambusia*, *Phalloceros*, and the Girardinini (*Toxus*) shows the following significant structural similarities. The distal constriction of ray 3 follows the same pattern and is a fundamental feature common to the three groups.

The anterior edge of this constricted area is crenulate in *Allogambusia*, slightly so in *Phalloceros*, and although smooth in most adult Girardinini it is crenulate in the intermediate stages of development of the gonopodium and in the adult of *Toxus*. The distal segments of ray 3 and anterior branch of ray 4 are short and increase gradually in size in *Allogambusia*, *Phalloceros*, and *Toxus*. Beginning at the area of constriction, ray 3 in all three groups develops a sharply edged flange anteriorly. In *Allogambusia*, there is a single, subterminal finger-like appendage on ray 3, in the same position and direction as the pair in the Girardinini. The last segment of ray 3 in *Allogambusia* is unmodified, but in *Phalloceros* and the Girardinini it is divided into two diverging halves which are prolonged into membranous appendages, greatly developed in *Phalloceros* and much reduced in the Girardinini. The segments at the base of the subterminal appendages of ray 3 in *Allogambusia* and in the Girardinini and those at the base of the terminal appendages in *Phalloceros* are modified into a supporting structure much the same way in all three groups. The anterior branch of ray 4 is much thicker than the posterior branch in the three groups, and both branches are characteristically and significantly separated distally with their tips slightly bent towards ray 3, in *Phalloceros* and in the Girardinini. The tip of the anterior branch of ray 4 is in contact with the tip of ray 3 in *Phalloceros* and in the Girardinini. The posterior branch of ray 4 has several pairs of retrorse serrae in the three groups (except *Toxus creolus*) and is constricted distally in *Phalloceros* and in the Girardinini. The anterior branch of ray 5 is similar in *Allogambusia* and *Phalloceros*, as well as the posterior branch, but in the Girardinini the anterior branch is more or less club-shaped by enlargement of some of its subterminal segments, and the posterior branch has several of its subterminal segments, each modified into a pair of retrorse serrae. In *Phalloceros* and the Girardinini, ray 3 is pigmented axially with melanophores in the same manner (see diagnosis, p. 286). This fundamental feature is not shared with any other member of the family Poeciliidae.

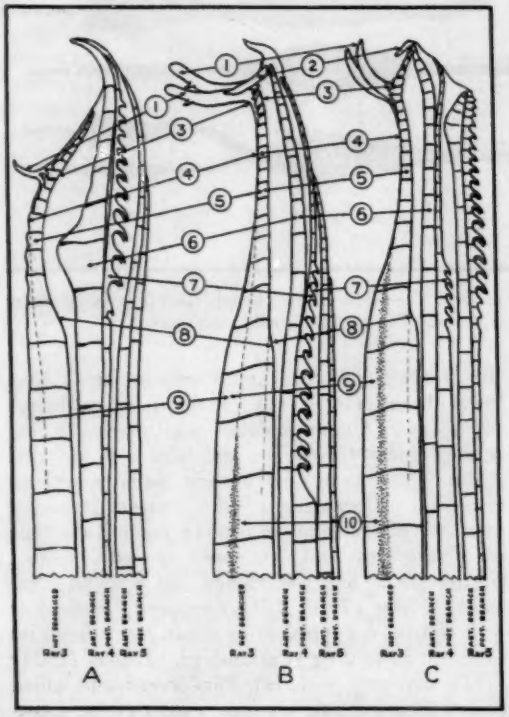


FIG. 7. Comparison of the gonopodia of: A, *Allogambusia*, B, *Phalloceros*, and C, *Toxus*. (1) Finger-like appendages. (2) Last segment of ray 3. (3) Subterminal segments of ray 3, modified into supporting structures. (4) Crenulations on anterior edge of ray 3. (5) Gradual increase in size of distal segments of ray 3. (6) Gradual increase in size of distal segments of anterior branch of ray 4. (7) Serrae on posterior branch of ray 4. (8) Distal constriction of ray 3. (9) Anterior edge of ray 3 flanged. (10) Pigmentation of ray 3 in *Phalloceros* and *Toxus*.

The modification of the distal end of ray 3 in *Allogambusia*, in the Girardinini, and in *Phalloceros* indicates relationship and a definite evolutionary trend, especially in the light of the other gonopodial characters. The simple appendage of ray 3 in *Allogambusia* would seem to represent the primitive stage of the more developed paired appendages of the Girardinini. This is confirmed by the development of the gonopodium in the Girardinini (see p. 290 and fig. 5) which shows that the finger-like appendages originate as a simple, shorter structure (*Allogambusia* stage) like that of *Allogambusia*. The modification of the terminal segment of ray 3 in the Girardinini, apparently represents an intermediate stage between *Allogambusia* and *Phalloceros*, the latter representing a final stage of distal migration and consolidation of the subterminal appendages with the modified terminal segment as it now appears

in the Girardinini. The greater development of the terminal appendages and the modification of the segments immediately below, into a supporting structure (as in *Allogambusia* and the Girardinini) in *Phalloceros*, seem to confirm this assumption.

There are at least six fundamental gonopodial characters common to *Allogambusia*, *Phalloceros*, and the Girardinini. Eighteen characters are common to *Phalloceros* and the Girardinini, seven to *Allogambusia* and the Girardinini, and eight to *Allogambusia* and *Phalloceros*. The fundamental structures associated with rays 3 and 4 of the gonopodium may be considered as homologous in the three groups and the immediate relationship and common origin of *Allogambusia*, *Phalloceros*, and the Girardinini definitely established. The relationships between the three groups, are shown in the following natural analysis based on gonopodial characters.

*1a.*—Terminal segment of ray 3 not modified. Anterior branch of ray 4 reaching well beyond the posterior branch, with two of its subterminal segments modified into an elbow-like swelling. Tip of ray 3 not in contact with tip of anterior branch of ray 4. Posterior branch of ray 4 not constricted distally, reaching beyond tip of ray 3, without serrae on its two terminal segments. Ray 3 not pigmented axially with melanophores. Gonopodium shorter, about 40 per cent of the length of the body without caudal, not reaching to vertical from posteriormost point of dorsal fin; its insertion nearer anterior margin of orbit than origin of dorsal fin.

*Allogambusia.*

*1b.*—Terminal segment of ray 3 more or less transverse in position, divided, each half prolonged into a more or less elongate, membranous appendage. Anterior branch of ray 4 about as long as the posterior branch; none of its segments modified into an elbow-like swelling. Tip of ray 3 in contact with tip of anterior branch of ray 4. Posterior branch of ray 4 constricted distally, not reaching beyond tip of ray 3, without serrae on ten or more of its terminal segments. Ray 3 pigmented axially with melanophores. Gonopodium longer, more than 40 per cent of the length of the body without caudal, reaching beyond vertical from posteriormost point of dorsal fin, its insertion nearer origin of dorsal fin than anterior margin of orbit.

*2a.*—Subterminal finger-like appendages of ray 3 free, not consolidated with those of the terminal segment and separated from them by 4 to 6 segments. Terminal appendages of ray 3 more or less weakly developed. Subterminal segments of anterior branch of ray 5 more or less enlarged, the distal end of the branch club-shaped. Posterior branch of ray 5 about as long as the anterior branch; several (5 to 16) of its subterminal segments, each modified into a pair of strong, retrorse serrae.

Tribe Girardinini.

*2b.*—Subterminal finger-like appendages of ray 3 not free; consolidated with those of the terminal segment. Terminal appendages of ray 3, strongly developed. Subterminal segments of anterior branch of ray 5 not enlarged, the distal end of the branch not club-shaped. Posterior branch of ray 5 shorter than the anterior branch; without serrae.

*Phalloceros.*

The gonopodial suspensorium is essentially similar in *Allogambusia*, *Phalloceros*, and the Girardinini, but in *Allogambusia* and *Phalloceros* the gonapophyses are more slender and the parapophyses somewhat less developed and higher.

Comparison of the members of the tribe Girardinini with *Allogambusia* and *Phalloceros* on the basis of characters other than those of the gonopodium also indicates common origin and immediate relationship in these groups. In the markedly adaptive mouth characters, *Phalloceros* is similar to *Dactylophallus* and *Girardinus*, and, with the exception of the primitive, open preorbital sensory groove and the number of dorsal rays (usually 7), it falls within the range of variation of the tribe Girardinini in all other quantitative and qualitative, non-gonopodial characters. There is, however, a combination of characters that distinguish *Phalloceros* at sight from the tribe Girardinini. *Allogambusia* resembles *Toxus* and *Glaridichthys* in mouth structure, but the teeth are of a primitive, generalized type, subconical, somewhat compressed, rather widely spaced and firmly set in the jaws. In general shape of the body and fins, *Allogambusia* resembles *Toxus*. The preorbital sensory organ in *Allogambusia* is an open groove as in *Phalloceros* and the juvenile stages of the tribe Girardinini. The dorsal fin has only 7 rays and the vertical cross bars on the sides of the body are narrower and better defined than in the tribe Girardinini. In the number of anal, caudal, and pectoral rays, scales, gill rakers, and vertebrae, *Allogambusia* is within the range of variation of the tribe Girardinini.

On the basis of gonopodial and other characters, it seems that *Allogambusia* is much more primitive than *Phalloceros*, the tribe Girardinini and the common ancestor of the last two groups. *Phalloceros* has retained certain primitive features of the gonopodium (ray 5 and segmentation of ray 3 and

anterior branch of ray 4) and the primitive characters involving the grooved preorbital sensory organ and the reduced number of dorsal rays. The tribe Girardinini has become specialized in ray 5 of the gonopodium, but there is indication of reduction in the serrae on posterior branch of ray 4. *Toxus* has retained the primitive segmentation of ray 3 and anterior branch of ray 4.

The common ancestor of the tribe Girardinini may be hypothetically reconstructed as a form intermediate between *Allogambusia* and *Toxus*, and very similar to the juvenile stage of the latter. Its characters and isolated geographical distribution indicate that *Phalloceros* is not an intermediate link between *Allogambusia* and the tribe Girardinini, but the present stage of a separate phyletic line very close to the latter group, derived from the same common ancestor, and persisting as a relict form. This is in accordance with Darlington's comments on "continuity of area" (1948: 3).

The taxonomic and geographical relationships between *Allogambusia* and the tribe Girardinini indicate that the ancestor of the Cuban group came from Central America. In fact, it is generally agreed that all the poeciliid fishes of Cuba and most of the other animals now occurring on the island, were derived in the past from Central America (Eigenmann, 1903; Schuchert, 1935; Myers, 1938). As pointed out by Darlington (1938: 287), the fauna of the West Indies was derived by immigration and not by partial extinction of a larger fauna of continental type. This is shown by the orderly distribution and relationships of animals "along what appear to be original migration routes." There is disagreement, however, as to the manner fresh-water fishes reached the island of Cuba.

## 2. THE MIGRATION WAS EFFECTED THROUGH FRESH WATER, BY MEANS OF A LAND CONNECTION BETWEEN EASTERN YUCATAN—BRITISH HONDURAS AND WESTERN CUBA

### MEANS OF DISPERSAL

There is disagreement among students of West Indian zoogeography as to the manner poeciliid fishes (or their ancestors) now living in the fresh waters of Cuba and other Antilles reached these islands from Central America.

Eigenmann (1903: 221) rapidly dismisses the problem by stating that: "The origin of the Cuban fresh water fish fauna . . . is simple of explanation . . . and that these forms probably reached Cuba by way of Yucatan." Matthew (1915: 35, 36) considers Cuba as an oceanic island and concludes that its fauna, including the fresh-water fishes, was derived from Central or South America by oversea migration. Barbour (1916: 2, 5) in criticism of Matthew takes an opposite view and states that ". . . the presence of . . . cyprinodont fishes [Poeciliidae] and many other groups of delicate organisms which are balanced to one particular environment cannot by any stretch of the imagination be distributed by flotsam and jetsam methods." Schuchert (1935: 106, 107) concludes that thirteen out of fourteen students of West Indian zoogeography ". . . see in both the faunal and floral biotas unmistakable evidence for more or less of migration via land from Central America." Darlington (1938) discussed in detail the origin of the fauna of the Greater Antilles and concludes that their animals, including poeciliid fishes, migrated to Cuba from Central America across water gaps, through the air by means of storms or through the sea by rafting or actual swimming. According to Darlington (*loc. cit.*: 284) "neither Dr. Barbour nor Dr. Hubbs thinks it likely that freshwater fishes have reached the Antilles through the air." Myers (1938) discussed the geographical distribution of fresh-water fishes in the West Indies and called attention to their importance in approaching zoogeographical problems. Although he did not come to any definite conclusions, it may be inferred from his paper that he does not think that fresh-water fishes, especially those of the tribe Girardinini, reached Cuba through the air or by the rafting method (*loc. cit.*: 343, 356), and that they might have reached the island by means of a land connection with Central America (*loc. cit.*: 362).

The possibility of transportation of small fresh-water fishes across water gaps in the past from Central America to the Greater Antilles through the sea and through the air by means of storms has been recently discussed in detail and accepted by Darlington (1938). My studies, however, indicate that the ancestor of the tribe Girardinini could not have reached Cuba by these means of dispersal as will be shown in the following discussion.

According to Darlington (1938: 277), the real differences between animals dispersed over water gaps and those dispersed over land connections are to be looked for in the "nature" of the organism and the "details" of its distribution. In other words, whether or not the animal is of a kind

easily dispersed over water and found on oceanic islands, or whether its distribution reflects the widths of water gaps and the direction of winds and currents at present as well as in the past.

Transportation of eggs by attachment to the feet of birds or by storms may be dismissed at the outset since the fishes of the tribe Girardinini, like all the other poeciliids, are ovoviviparous.

Intense exploration and observation in the field by the present writer and others, covering all types of habitats and seasons throughout the entire island of Cuba during many years, have failed to produce fishes of the tribe Girardinini from salt, brackish, or fresh water with a Cl content higher than 1,000 parts per million (19,000 parts per million in full strength sea water). The greater number of species occurs between 100 and 500 feet above sea level (see table 2), and none have been found to occur below 5 feet.[4] Every year during the rainy season, steep streams containing girardinin fishes become torrential and many individuals are carried down and killed by the force of the current, predaceous fishes, or the increased salinity. There are many streams of this kind in Cuba, and it would seem logical to assume that, since most of these fishes are not lovers of fast water, at least some of the species would have adapted themselves to the less turbulent estuarine conditions. They have failed to do so, however, apparently owing to competition, predator pressure, increased salinity, or a combination of these factors.

Laboratory experiments by me have shown that transfer from fresh to full strength sea water will invariably kill girardinin fishes in 30 to 90 minutes. Analyses of water samples obtained in the field during several years throughout the island of Cuba, at various altitudes and types of habitat, reveal that the fishes of the tribe Girardinini naturally inhabit waters of a Cl content ranging from 20 to 1,000 parts per million (usually 25 to 50 and very rarely above 100). To these salinities corresponds a *p*H range of 6.25 to 7.75, with an average of 7.25.

Myers (1938: 342–345; 1949) groups fresh-water fishes according to their ability to survive in salt water into "primary" and "secondary divisions." He includes in his primary division fishes which "are very strictly confined to fresh water" and considers the family Poeciliidae as a member of the secondary division of fishes which "behave like true fresh-water fishes, but . . . show a less sharp restriction to fresh water." He (1938: 344, footnote) admits that a few members (characins, carps, catfishes) of his strictly fresh-water primary division "enter brackish water in estuaries, but none is known to be able to survive in the sea for more than a few hours" (see also Gosline, 1944: 214; and Darlington, 1948: 8). These fishes belong to the "primarily fresh-water order" Ostariophysi which, incidentally, comprises more than 100 species of *strictly marine* catfishes (Dorichthyidae, Ariidae, Plotosidae) derived from fresh-water ancestors.

About 90 per cent of the some 140 known species of poeciliid fishes are strictly confined to fresh water and the few forms found in brackish or salt water also occur and are more abundant in fresh water. The primitive poeciliid *Curtipenis elegans* ancestral to *Mollienisia* and *Limia* of which some species can, and do, live in salt water (*M. latipinna, L. vittata*), behaves as a strictly fresh-water fish confined to the mountain streams of the island of Hispaniola (Rivas and Myers, 1950: 294). There is reason to believe that poeciliid fishes originated and have remained confined to fresh water until comparatively recent times when a few forms have partially succeeded in adapting themselves to the coastal marine habitat in very shallow protected waters never far from estuaries. The fishes of the tribe Girardinini never voluntarily enter even brackish water and are unable to survive in sea water for more than 90 minutes as already indicated. Myers' statement (1938: 356) that "the most striking feature of the fresh-water fish fauna of the West Indies is the complete absence of members of the primary division of fresh-water fishes . . ." should therefore be considered with caution. As pointed out by Simpson (1952: 169) some confusion has arisen from failure to be certain that particular groups (for instance among fresh-water fishes) really belong in the category of organisms that ". . . cannot live long or develop normally in, on, or above the sea, let alone maintain populations there."

Paleontological and paleoecological evidence have demonstrated that inability to survive in sea water of fresh-water groups is a physioecological character that requires a long time (measurable in geologic periods) to be acquired or lost. It certainly would take longer than the assumed age of the tribe Girardinini which is estimated to have originated sometime during the Late Miocene or Early Pliocene (see p. 315). Characins are known

[4] The effect of the tides is never felt in Cuban streams, above 3 feet.

to have existed as fresh-water fishes since the Eocene, and Smith Woodward (*in* Regan, 1908) has stated that " all fossil Cyprinodonts known are from fresh-water or estuarine deposits, chiefly lake deposits."

It seems to me that similarly important factors other than the ability of certain fresh-water fishes to survive in sea water have been completely ignored in attempting to solve the problem of the derivation of small, delicate forms like those of the Cuban tribe Girardinini. I refer in particular to their narrow bathic and food restrictions. Observations in the field and in the laboratory indicate that the fishes of the tribe Girardinini are strictly stenobathic and apparently sensitive to pressure. They seldom occur at the surface and never at depths of more than six feet. The preferred zone seems to be between six inches and four feet, according to the nature of the bottom, the type of aquatic vegetation and the depth of the water. They do not occur in open water and never voluntarily stray more than about twenty feet from the shore or travel long distances along the bank. As demonstrated by their mouth structure, observed behavior, and examination of stomach contents, girardinin fishes are phytophagous, limnophagous, or both, and strictly dependent on muddy bottom and/or the aquatic vegetation for food and protection. They do not occur in situations where mud and aquatic vegetation are entirely absent (see also comments by Schaeffer, 1952: 228, on primary fresh-water fishes).

Hubbs (*in* Darlington, 1938: 284) suggested "that some or all of the few sorts of freshwater fishes which have reached Cuba could live for sometime in sea water, and that they may possibly have crossed through the sea, possibly at a time when heavy rains or a large river had somewhat sweetened the sea's surface." Hubbs probably did not know at the time that girardinin fishes cannot live in sea water, and that even if they could, their delicate structure and narrow bathic and food limitations would have amply prevented their crossing a wide water gap. It must not be forgotten that fresh-water forms, especially those like girardinin fishes are securely bound to the land, and that on the land, "they are inescapably confined to their own particular drainage systems and can migrate from one isolated stream basin to the next only through the slow physiographical change of the land itself," as appropriately pointed out by Myers (1938: 343).

As already indicated in the first postulate (p. 282), the ancestor of the tribe Girardinini must have been of a type intermediate between *Allogambusia tridentiger* of Panama and the genus *Toxus* and essentially similar to *Allogambusia* and the present members of the tribe in its general ecological limitations. The most primitive member of the tribe (*Toxus serripenis*) is well adapted to, and isolated in, the headwaters of Rio Taco Taco (800 to 1,000 feet above sea level) in the southern drainage of the province of Pinar del Rio, above and by a series of adjacent water falls totalling about 300 feet in height, and absolutely impassable to fishes. These falls are located in the oldest region of Cuba and are believed to have existed (at least as a barrier to poeciliid fishes) since the Pleistocene.

Correlation of the phylogenetic history of the members of the tribe Girardinini with their habits, altitudinal and geographical distribution indicates early radiation (primary phyletic lines) and dispersal from a highland habitat towards the lowlands, and subsequent reinvasion of the highlands and horizontal dispersal by stream capture or periodic flooding of the lowlands, not along coastal waters. It is also significant that *Allogambusia tridentiger*, which as a primitive form closely related to the ancestor of the tribe Girardinini, occurs in the highlands on both slopes of Panama, thus indicating long confinement in fresh water and dispersal by stream capture.

There is therefore, no evidence for assuming that the ancestor of the tribe Girardinini could have reached Cuba via salt water and then worked its way upstream, especially at a time (Upper Miocene and/or Lower Pliocene) when there was no coastal plain and the streams were probably impassable to poeciliid fishes. The isolated taxonomic and geographic position of the tribe in the fresh waters of Cuba, its inability to survive in sea water, and its narrow bathic and food limitations are strong evidence that these fishes have been confined to the island for a long time and could not, and probably have not crossed water gaps to or from Yucatan, Florida, Hispaniola, or Jamaica.

Dispersal through the air of girardinin and other poeciliid fishes from Central America to the Greater Antilles by hurricanes[5] or water spouts

[5] Hurricanes are rotary, circular tropical storms with a calm center and up to 500 miles in diameter. They are frequent in the West Indian region, especially during August through October. In the northern hemisphere, the winds rotate counterclockwise about the center of

TABLE 1

FISHES OF THE FAMILY POECILIIDAE OCCURRING ON EACH SIDE OF THE YUCATAN CHANNEL

| Outer Yucatan (Hubbs, 1936) | Western Cuba |
|---|---|
| Subfamily Gambusiinae | Subfamily Gambusiinae |
| Tribe Gambusiini | Tribe Gambusiini |
| Genus *Gambusia* | Genus *Gambusia* |
| *G. nicaraguensis* | *G. punctata* |
| *G. yucatana* | *G. puncticulata* |
| Genus *Belonesox* | Tribe Quintanini |
| *B. belizanus* | Genus *Quintana* |
| Tribe Heterandrini | *Q. atrizona* |
| Genus *Pseudoxiphophorus* | Tribe Girardinini |
| *P. bimaculatus* | Genus *Toxus* |
| Subfamily Poeciliopsinae | *T. serripenis* |
| Genus *Allophallus* | *T. creolus* |
| *A. kidderi* | Genus *Glaridichthys* |
| Subfamily Poeciliinae | *G. uninotatus* |
| Tribe Poeciliini | *G. falcatus* |
| Genus *Mollienesia* | Genus *Allodontium* |
| *M. sphenops* | *A. cubense* |
| *M. latipinna* | Genus *Girardinus* |
| *M. velifera* | *G. microdactylus* |
| | *G. metallicus* |
| | Subfamily Poeciliinae |
| | Tribe Poeciliini |
| | Genus *Limia* |
| | *L. vittata* |

does not seem to have been possible in the past, nor is it possible at present for reasons already discussed and the following.

As correctly indicated by Darlington (1938: 279 and fig. 1) ". . . any hurricane which passes through or near the Yucatan Channel may cause a wind to blow for a time from Yucatan to Cuba, no matter in what direction the storm center is moving." This water gap (about 110 nautical miles in width) is precisely the area in the West Indies where hurricanes are strongest and pass more frequently. An analysis of the poeciliid fauna of either side of the Yucatan Channel (table 1) does not show any evidence of over water dispersal through the air or through the sea at present or during the recent past.[6] The only genus (*Gambusia*) common to Yucatan and western Cuba includes well distinct and not very closely related species in those regions, and, in spite of how infrequent or sporadic such a method of dispersal might be, hurricanes certainly are not so selective as to have transported only *Gambusia* across the Channel in one direction. The same reasoning applies to other water gaps between Central America and the Greater Antilles or between the latter themselves. As to better conditions for hurricane dispersal during the less recent past (see Darlington, 1938: 298, fig. 5), it must be remembered that the outer Yucatan Peninsula has existed only since the Pleistocene, and that its present poeciliid fauna is the product of a comparatively recent migration from the adjacent regions of Central America as clearly indicated by its relationships (Hubbs, 1936: 160). The land connection between British Honduras and western Cuba postulated in the present paper (see p. 302), is assumed to be a comparatively ancient one which existed at a time (Upper Miocene or Lower Pliocene) when probably only a few poeciliids, including the old girardinin ancestor, existed and the family was beginning to disperse.

In trying to prove a direct dispersal of animals (including poeciliid fishes) through the air by hurricanes, from Central America to the Greater Antilles, Darlington (1938: 279) offers the following statement:

> Besides the few hurricanes which have traveled from the present boundaries of Central America to the Greater Antilles, others have crossed from above the submerged Honduras-Nicaraguan banks to the islands. If these banks were elevated, as geologists suppose they were, the number of storms crossing from the mainland to the islands would be increased.

I agree with the above statement, except its implication that the poeciliid fishes of Cuba might have been derived *directly* from the Honduras-Nicaraguan region through the air by means of these hurricanes, as shown in his map (*loc. cit.*: 278, fig. 1). There is no direct relationship between the poeciliid fishes of Cuba and those of Central America indicating the possibility of such a dispersal at present or during the recent past. Furthermore, his paleogeographic map (*loc. cit.*: 298, fig. 5) of the western Caribbean region shows too close an approximation between Cuba and Central America by including Misteriosa Bank as a part of the emerged Honduras-Nicaraguan Bank in contradiction with the geological evidence (Schuchert, 1935). Misteriosa Bank lies about 100 nautical miles north of the Honduras-Nicaraguan Bank and is separated from the latter by the middle Caribbean basin (western extension of the Bartlett Deep) with maximum depths of over 3,000 fathoms (average depth 1,500 fathoms). I

the storm and may reach a velocity of 200 miles per hour or more. The velocity of progression averages about 12 miles per hour. See also Darlington, 1938: 278–282.

[6] The direction and velocity of the Gulf Stream represent additional evidence against the possibility of actual swimming across the Yucatan Channel by poeciliid fishes.

do not understand why Darlington should correctly indicate the islands of Little Cayman and Cayman Brac as part of eastern Cuba during that time, and leave the island of Grand Cayman submerged.

According to Darlington's mathematical interpretation of dispersal across water gaps, and to his meteorology and paleogeography (1938: 274–276, 298, fig. 5), the poeciliid fauna of western Cuba should exhibit a greater, or at least the same degree of relationship with Honduras-Nicaragua, as that of Jamaica and Hispaniola. The truth is that the poeciliid fauna of western Cuba is much less related to that of Honduras-Nicaragua than that of Jamaica and Hispaniola. As far as Cuba is concerned, this does not support his statement (*loc. cit.*: 283) that ". . . the known facts suggest that the position of the islands, with the narrowest water gap on the Central American side in the past, and the direction and nature of storms, have favored immigration of organisms into the Greater Antilles chiefly from Central America, even if there has never been a complete land connection." Furthermore, the absence of *Mollienisia* in Jamaica and its presence in Hispaniola and the Honduras-Nicaragua region contradicts his statement (*loc. cit.*: 276) that ". . . organisms which are dispersed across water from a continent to a series of islands are . . . likely to reach the nearest islands first and very unlikely to skip near and populate far islands directly." The absence of *Mollienisia* in Jamaica may be explainable on paleogeographic grounds other than the width of present or past water gaps, but that is beyond the scope of this present work.

Darlington's efforts to prove that poeciliid fishes, among other small animals, may have been dispersed through the air in the past by hurricanes seem to be also weakened by several paleoclimatic factors. He correctly admits that in the past, meteorological conditions in the Antillean region were "very different from what they are now," and that "Before the Pleistocene, the climate of the whole world was much more uniform than it is now." But these statements (1938: 283) were aimed to prove that the direction of progression of hurricanes had been more erratic in the past, and overlooked or ignored the possibility that these storms could have been also much less frequent and strong. I do not see how erratic dispersal can be reconciled with the orderly distribution and relationships of the West Indian fauna.

Water spouts are known to be responsible for the transportation of small fishes through the air (Gudger, 1921, 1929*a*, 1929*b*, 1946; Bajkov, 1949). Their effect is very local, however, and as pointed out by Myers (1938: 343): ". . . fish distribution is much more regular and understandable than it would be if these unusual methods of transportation were of much importance." In spite of the common occurrence of water spouts in Cuba, the geographical distribution of the fishes of the tribe Girardinini is too well correlated with the physiographic history of the island even to suggest the possibility of dispersal by those storms. Water spouts are always short-lived and do not carry for more than a few miles. There are no "rains of fishes" reported from Cuba.

In addition to the arguments already discussed, one of the strongest objections to over-water dispersal of West Indian poeciliid fishes is the presence of certain species on one of both sides of a water gap and their absence on the other, even when conditions seem to be most favorable for such a kind of dispersal. *Poecilia vivipara*[7] is a fresh- and salt-water poeciliid abundantly distributed in Puerto Rico and entirely absent in Hispaniola (and westward) in spite of the fact that ocean currents and prevailing (trade) winds steadily flow from the former to the latter island across Mona Passage (fig. 8 (1)). The normal movement of hurricanes is also from Puerto Rico to Hispaniola. One or two species of *Gambusia* are commonly found in salt water along the coast of eastern Hispaniola and yet the genus is entirely absent in Puerto Rico and eastward. Mona Passage is the shallowest and one of the narrowest water gaps in the West Indies. The shortest distance between Hispaniola (Cabo Engaño) and Puerto Rico (Punta Jiguera) is of about 60 nautical miles and the maximum depth about 290 fathoms (average depth about 100 fathoms). The comparatively large Mona Island situated about halfway between Puerto Rico and Hispaniola could even be considered as a suitable "stepping stone" for an over-sea migration of *Poecilia* or *Gambusia* by reducing the width of the gap more than 30 miles. The shortest distance between the insular shelves of Puerto Rico and Hispaniola is 28 nautical miles. These conditions are certainly better for oversea dispersal of poeciliid fishes than those theoretically proposed by Darlington (1938:

[7] This is the only species of the family Poeciliidae, in fact, the only cyprinodont known from Puerto Rico (Evermann and Marsh, 1902: 97. Nichols, 1929: 210. Hildebrand, 1935: 51).

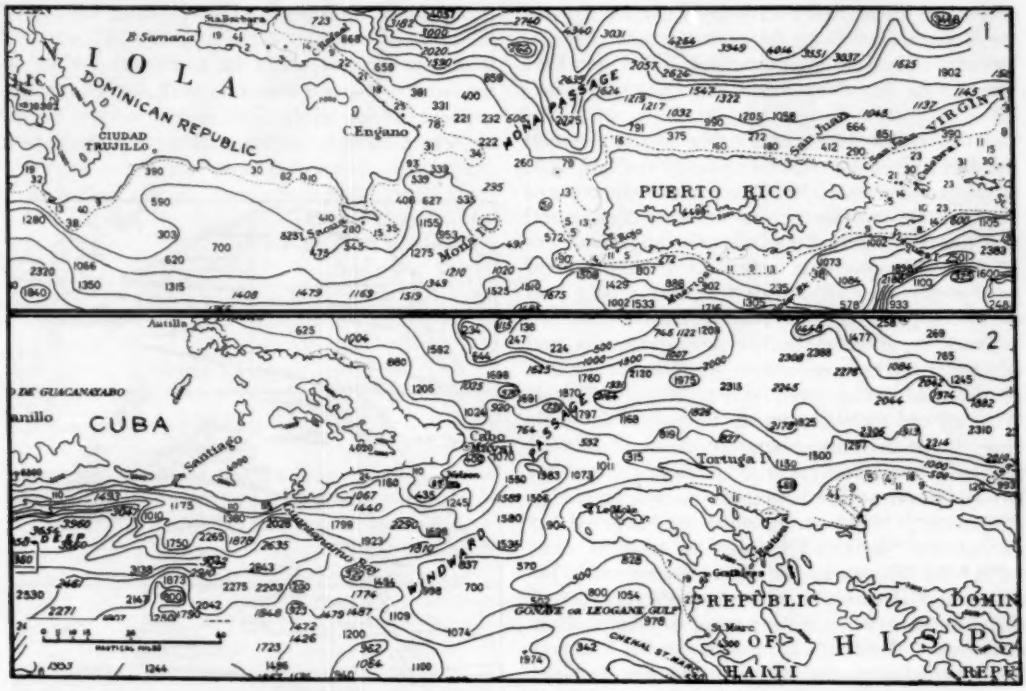


FIG. 8. (1) Mona Passage and neighboring areas. (From U. S. Navy Hydrographic chart No. 5487.) The genera *Gambusia, Limia* (Poeciliidae), and *Cichlastoma* (Cichlidae) are present in Hispaniola but absent in Puerto Rico. *Poecilia vivipara* (Poeciliidae) is present in Puerto Rico but absent in Hispaniola. Compare with conditions on either side of Windward Passage below. (2) Windward Passage and neighboring areas. (From U. S. Navy Hydrographic chart No. 5487.) The genera *Gambusia, Limia* (Poeciliidae), and *Cichlasoma* (Cichlidae) are common to Cuba and Hispaniola.

298 and fig. 5) for the past. As far as poeciliid fishes are concerned, there are no species common to the mainland and the islands or occurring on more than one island.

Darlington (1938: 285) argues that absence of the same species on each side of a water gap is no proof that animals cannot cross it, because water gaps would only occasionally allow the crossing of one or very few individuals which would not introduce enough germ plasm to interfere with divergence. His reasoning is sound as far as interfertile species are concerned, but it does not explain the unequal number of species of poeciliid fishes on each side of *every* water gap in the West Indies, or conditions such as those found on each side of Mona Passage. *Poecilia* and *Gambusia* are not interfertile and belong to different and unrelated subfamilies of the Poeciliidae.

## LAND CONNECTION

In the light of the evidence presented in these pages, poeciliid fishes, especially those of the tribe Girardinini, do not seem to be of a kind dispersed over water or found on oceanic islands,[8] and their distribution and relationships in the West Indies do not reflect the widths of water gaps or the direction of winds and currents at present or in the past. The isolated position of the tribe Girardinini, taxonomically and geographically, is good

[8] Poeciliid fishes do not occur on any of the oceanic islands close to the range of the family, such as Bermuda, the Galapagos, Cocos, Tres Marias, etc. Tres Marias Islands are only 35 nautical miles off the Pacific coast of Mexico (State of Nayarit). Cocos Island, in the Pacific, is about 250 nautical miles off Costa Rica which is one of the regions richest in poeciliid fishes (species and individuals). Bermuda has received, presumably by means of the Gulf Stream, a great deal of West Indian coastal and estuarine fishes but no poeciliids.

proof that these fishes have been confined to the fresh waters of Cuba for a long time, and, as already discussed, their ancestor could not have reached the island by over-water dispersal of any kind.

It seems therefore reasonable to assume that the ancestor of the tribe Girardinini reached Cuba in the past by means of a direct land connection or isthmian link which existed between that island and Central America, and that the migration was effected through fresh water by stream capture and/or flooding. Evidence for such a land connection is given in the following discussions.

Students of West Indian paleogeography and biogeography have repeatedly postulated two land connections during the Tertiary, between Central America and the West Indies, to explain the presence of certain organisms in those islands or purely on geological grounds. One of these, commonly known as the Honduras-Nicaragua bridge (Schuchert, 1935) is assumed to have existed during the Miocene-Pliocene and to have connected the Honduras-Nicaragua region with Jamaica and Hispaniola. Very extensive parts of this former isthmus now remain as the shallow submerged Honduras-Nicaragua shelf, Rosalind and Pedro banks, the island of Jamaica and the Peninsula of Tiburon in Haiti. The other land connection is assumed to have existed also during the Miocene-Pliocene between British Honduras-eastern Yucatan and western Cuba.

The absence of girardinin fishes or their relatives in the West Indies outside of Cuba [9] and the assumed location of the center of origin of the tribe in western Cuba (see p. 310) indicate that the ancestor of the tribe arrived on the island by way of the British Honduras-Eastern Yucatan connection. According to the geological and physiographical evidence (Vaughan, 1918; Schuchert, 1935; Massip, 1942; Bermudez, 1950), the history of this former isthmian link may be reconstructed as follows (fig. 9).

During the Middle Miocene, the older Yucatan and western Cuba structures which had been peneplaned to base level and later submerged (Lower Miocene), were subjected to opposed lateral pressures producing a general folding in the area. These pressures were caused by the gradual sinking of the Gulf of Mexico and northwestern Caribbean plates, and were exerted in a

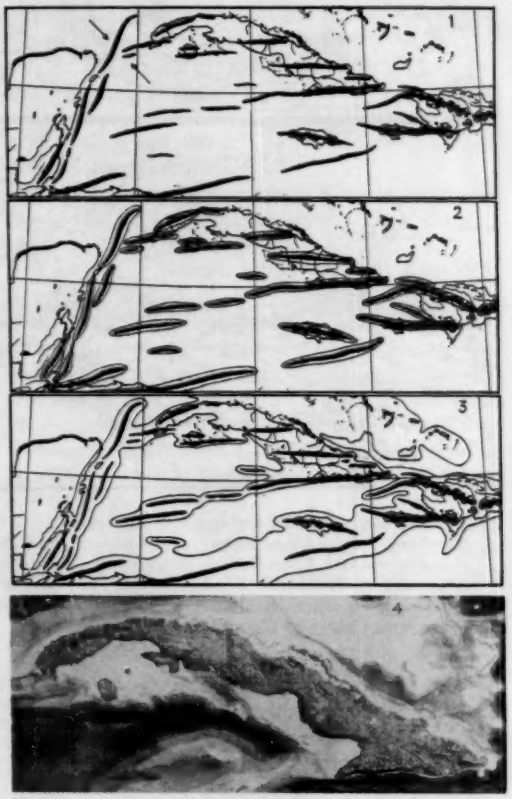


FIG. 9. Origin of the Yucatan-Cuba isthmian link and neighboring areas. (1) The newly formed Middle Miocene anticlines (in solid black) emerge as narrow, elongate islands. Arrows indicate the approximate direction of pressures. (2) Subaerial and marine erosion attack the exposed land and the eroded material is deposited around the islands filling in the intervening arms of the sea and gradually enlarging the islands. (3) The continued process of erosion, deposition, and general emergence finally establishes a land connection between Central America and western Cuba. Other land connections are also formed, and the basic structure of the island of Cuba is permanently established. (4) Present physiographic aspect of the island of Cuba and the surrounding sea bottom. From a plastic model. (Photograph courtesy of the University of Havana.)

[9] The poeciliid fish fauna of the West Indies, with the exception of Cuba, comprises the following genera: *Gambusia* (3 species in the Bahamas, 4 in Hispaniola, 4 in Jamaica, 1 in Grand Cayman), *Curtipenis* (1 in Hispaniola), *Molliencsia* (2 in Hispaniola), *Limia* (7 in Hispaniola, 1 in Jamaica, 1 in Grand Cayman) and *Poecilia* (1 in Puerto Rico and the Lesser Antilles). In addition to the tribe Girardinini, Cuba has 7 species of *Gambusia*, the monotypic genus *Quintana* (*atrizona*) and one *Limia* (*vittata*).

southeast and northwest direction respectively. The anticlines thus formed emerged as narrow, elongate islands and the corresponding synclines remained as shallow arms of the sea between them (fig. 9 (1)). These anticlines seem to have extended to the southwest into Central America along the eastern shore of Yucatan and remain now as the Cockscomb mountains of British Honduras and the Organ Mountains of western Cuba. According to Schuchert (1935: 398), "These folds of western Cuba represent the Ancestral Organ Mountains. South of Cuba these folds and those of the isle of Pines may have turned more sharply southwest into southern Yucatan, and if so, are now buried by young Cenozoic deposits."

As the islands emerged, subaerial and marine erosion began to attack the exposed land and the eroded material gradually filled and shallowed the intervening arms of the sea (fig. 9 (2)). This process and continued general emergence contributed to the enlargement and approximation of the islands until a continuous isthmian link was established between Central America and western Cuba (fig. 9 (3)). A long period of stability followed (Upper Miocene-Pliocene) during which continued marine and subaerial erosion reduced the isthmus to a peneplain and a very active process of stream capture must have taken place. It is during this period that the ancestor of the tribe Girardinini is assumed to have migrated into western Cuba. Following this period, profound faulting took place throughout the entire Caribbean area, and western Cuba was then permanently isolated from Central America by submergence of the isthmus through downfaulting during the second half of the Pliocene. Schuchert (1935: 383, 384) says that ". . . the western side of the Antillean sea, seemingly at a somewhat earlier period (late Pliocene), was faulted into great depths (about a mile), with a consequent permanent separation of Yucatan from Cuba"; and on p. 498: "The present great depths of the . . . Yucatan end of the Antillean Sea, . . . developed with the northeast-southwest faulting of the late Pliocene, when for the first time the Caribbean mediterranean connected widely and deeply with the Gulf of Mexico through Yucatan Channel."

Examination of a bathymetric chart of the Gulf of Mexico-Caribbean region (fig. 10) shows that the bottom in the Yucatan Channel area forms a distinct, well-elevated platform as compared with the northwestern Caribbean Basin. The 1,100 fathom line joins Cuba with Yucatan and the average depth of the Channel is of about 700 fathoms, whereas the deepest areas of the Gulf of Mexico (2,000 fathoms) and the northwestern Caribbean (3,000 fathoms) are not far to the north and south respectively. I believe that the submarine physiography of the Yucatan Channel and neighboring areas is significant in connection with the Yucatan-Cuba isthmian link and that its former existence will not be definitely proved or disproved until the submarine geology of the area is thoroughly investigated (see also comments by Ewing, 1952: 90). If a dry land connection really existed between Yucatan and western Cuba during the period assumed in this discussion, submarine exploration (borings) of the Yucatan Channel should show the upper layers of the bottom to be chiefly composed of marine Lower Miocene with Pliocene and Pleistocene marine deposits immediately above it. Middle and Upper Miocene, and early Pliocene deposits, if present, should be scarce and/or of subaerial or fresh-water origin.

In addition to uplift by folding, former prepleistocenic changes in sea level might have been partly responsible for the establishment of a dry land connection between British Honduras-Yucatan and western Cuba during the Miocene-Pliocene. I refer in particular to the evidence afforded by the deep (1,000 fathoms or more) submarine canyons found off river mouths, in the continental shelves throughout the world (Shepard, 1948: 207–250) and to the recent discoveries of Ewing (1948: 275–294; 1949: 611–640) in the Atlantic Ocean Basin.[10]

It has been recently pointed out to me (Dr. G. S. Myers, personal communication) that, if a land connection bearing fresh-water streams existed between Central America and western Cuba, then the absence in Cuba of certain fresh-water fishes (Characidae, Gymnotidae, Cyprinidae, Ameiuridae, Pimelodidae) which occur in Central America, requires explanation.

The family Characidae comprises over 1,000 species in South America and about 30 in Mexico and Central America, most of which also occur in South America. Only one species (*Astyanax fasciatus*) extends northward into the Rio Grande

[10] According to recent investigations, submarine canyons seem to have been excavated by subaerial river erosion implying a lowering of 1,000 or more fathoms for the present level of the sea in the not too remote past. The recent discovery of beach-like terraces and sand deposits of coastal origin in the Atlantic Ocean, more than 1,000 fathoms deep, seems to support this hypothesis.

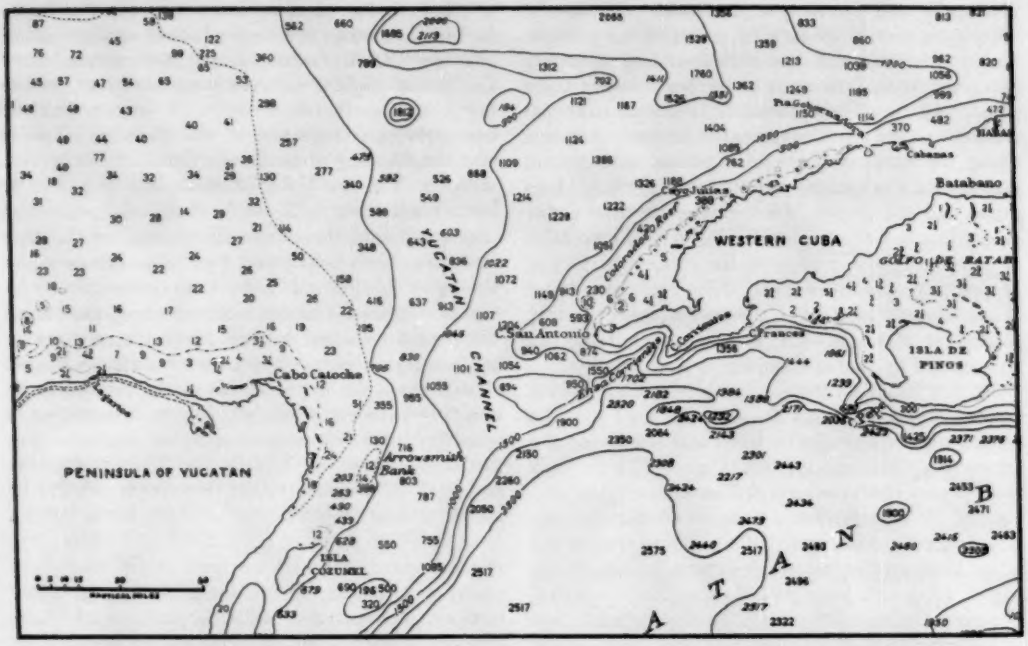


FIG. 10. Bathymetry of the Yucatan Channel area. (From U. S. Navy Hydrographic chart No. 5487.)

system and about 26 occur only in eastern Panama. About six species occur in Central America proper, between the Isthmus of Tehuantepec and western Panama. *Astyanax fasciatus* is the only species known from the British Honduras-Yucatan region, and its range extends southward well into South America (Brazil). The Gymnotidae comprises 30 or more species in South America and only one (*Gymnotus carapo*) extends northward into Central America (Guatemala) from the Rio La Plata system in Argentina. The North American family Cyprinidae has over 400 species, in Canada, in the United States, and in Mexico, with only one species (*Carpiodes meridionalis*) extending southward into western Guatemala. The Ameiuridae comprises more than 30 species in North America and only *Ictalurus meridionalis* extends southward into western Guatemala. The South American family Pimelodidae has over 250 species in South America and only about 20 in Central America, two or three of which extend into southern Mexico. The twenty or so nominal species of Pimelodidae occurring in Mexico and Central America all belong to the genus *Rhamdia* and are very closely related. Recent variation studies on certain Central American forms of this genus (Hubbs, 1936: 179–207) indicate that many of these nominal species will eventually be construed as mere local subspecies or races.

The pattern of distribution and the geographical and taxonomic relationships of these fresh-water fishes in Central America indicate their recent invasion of the region comprised between the Isthmus of Tehuantepec and western Panama, from North and South America. This region, according to the paleogeographic evidence (Schuchert, 1935: 314–385; 551–621), was isolated from North and South America by the Tehuantepec (Eocene-Pliocene) and Nicaragua-Costa Rica (Oligocene-Miocene) portals during most of the Tertiary (see also Gosline, 1944: 217–220). As already discussed (p. 303), western Cuba was permanently isolated from Central America at the time (Pliocene) when the latter was rejoined to North and South America (see also Schaeffer, 1952: 228), and the northern Cyprinidae Ameiuridae) and southern (Characidae, Gymnotidae, Pimelodidae) fresh-water fishes in question arrived too late to be able to penetrate into Cuba.

The above explanation may equally apply to

representatives of other groups of living and extinct animals (pit-vipers, perissodactyls, artiodactyls, proboscideans, carnivores) whose absence in Cuba has been considered as opposed to a former direct land connection between that island and Central America (Gadow, 1905; Matthew, 1918).

Eigenmann (1903: 221) was of the opinion that the fresh-water fishes of western Cuba reached the island "by way of Yucatan," but the distribution and relationships of some of them (*Gambusia, Limia, Cichlasoma*) indicate arrival by way of Hispaniola and Jamaica via the former Honduras-Nicaragua land bridge. However, *Atractosteus tristoechus* (Lepisosteidae) and *Quintana atrizona* (Poeciliidae) are confined to the fresh waters of western Cuba and their relationships indicate a direct western arrival from Central America with the ancestor of the tribe Girardinini over the same migratory route.

The reptiles and amphibians (Barbour and Ramsden, 1919) strongly indicate that Cuba has been connected with Yucatan in the past, and according to Simpson (1895) the distribution and relationships of the land and fresh-water mollusks of Cuba suggest a former land connection with Yucatan.

## 3. SPECIATION IN THE TRIBE GIRARDININI HAS OCCURRED CHIEFLY THROUGH ADAPTIVE RADIATION, AND ITS CENTER OF ORIGIN WAS LOCATED IN WESTERN CUBA

### ECOLOGY AND BEHAVIOR

According to the taxonomic analysis and phylogenetic interpretation as discussed earlier in this study, speciation in the tribe Girardinini seems to have occurred through adaptive radiation involving chiefly feeding characters, and simultaneous or subsequent geographical isolation. This is further confirmed by correlation of structure and behavior with habitat and occurrence, as shown in the following ecological analysis based on continued laboratory and field observations and examination of stomach contents. The more general ecological features concerning the tribe Girardinini as a group have already been discussed.

### *Ecological Analysis of the Tribe Girardinini*

#### Structure and behavior

*1a.*—Mouth comparatively small. Jaws, lips, and dentition especially adapted for gnawing and biting through relatively solid matter. Food: diatoms, algae, leaves of higher aquatic plants, detritus and occasionally insect larvae. Observed behavior: midwater swimmers seldom occurring at or near the surface or bottom. Feeding effected mostly on the aquatic vegetation by gnawing or biting off. (*Glaridichthys.*)

*2a.*—Body and fins well adapted for life in running water. Pigmentation well developed indicating origin in clear water. Sensitive to high Cl content and warm, turbid poorly oxygenated water. Thriving best in temperatures about 25° C.

*Glaridichthys uninotatus.*

*2b.*—Body and fins not well adapted for life in running water. Pigmentation weakly developed, indicating origin in turbid water. Habitat tolerance range wide, but thrives best in warm, turbid water.

*Glaridichthys falcatus.*

*1b.*—Mouth comparatively medium sized. Jaws, lips, and dentition generalized; not especially adapted for gnawing, biting through solid matter, scraping, or sucking. Food: algae, aquatic plants, and detritus, and rarely insect larvae. Observed behavior: midwater swimmers never occurring at the surface and seldom on the bottom. Feeding effected on the aquatic vegetation by gnawing, biting, scraping and sucking. (*Toxus.*)

*2c.*—Body and fins especially well adapted for life in running water. Pigmentation strongly developed, indicating origin and long occurrence in clear water. Very sensitive to high Cl content and warm, turbid poorly oxygenated water. Thriving best in temperatures below 25° C.

*Toxus serripenis, T. creolus.*

*1c.*—Mouth comparatively medium sized. Jaws, lips, and dentition relatively generalized but better adapted for scraping and sucking than gnawing and biting. Food: algae, mud, detritus and occasionally insect larvae. Observed behavior: midwater and bottom swimmers seldom occurring at the surface. Feeding effected on the bottom and aquatic vegetation mostly by scraping and sucking. (*Allodontium.*)

*2d.*—Body and fins relatively generalized but not well adapted for life in running water. Pigmentation rather weakly developed, indicating origin in rather turbid water. Habitat tolerance range wide, but seems to thrive best in warm turbid water.

*Allodontium cubense.*

*1d.*—Mouth comparatively large. Jaws, lips and dentition especially adapted for scraping and sucking. Food: diatoms, algae, detritus, mud, fine sand, and occasionally insect larvae. Observed behavior: midwater and bottom swimmers occasionally occurring at or near the surface.

Feeding effected on the bottom and aquatic vegetation by scraping and sucking. (*Dactylophallus, Girardinus.*)

*2e.*—Body and fins more or less adapted for life in running water. Pigmentation well developed, indicating origin in clear water. Habitat tolerance very wide but seems to thrive best in clear, moving water.

*Dactylophallus denticulatus.*

*2f.*—Body and fins not well adapted for life in running water. Pigmentation well developed, indicating origin in clear water. Habitat tolerance range wide but seems to thrive best in clear, stagnant or very sluggish water.

*Girardinus metallicus.*

*2g.*—Body and fins more or less adapted for life in running water. Pigmentation very well developed, indicating origin in clear water. Sensitive to high Cl content and warm, turbid, poorly oxygenated stagnant water.

*Girardinus microdactylus.*

## Habitat and Occurrence

*1a.*—Highland or mountain habitat, usually 100 to 1,000 feet above sea level. Water always clear, cool, and well oxygenated; never stagnant, the current rapid or of moderate velocity. Chlorides (Cl) usually below 50 p.p.m. Annual temperature range 21° to 28° C. (mean 24.5). Bottom hard, composed chiefly of smooth rock, stones, or gravel; sand present; mud nearly absent. Aquatic vegetation scarce, except for algal growth and diatoms on rocks and stones. Plankton absent. Small aquatic insect larvae present. Predators almost entirely absent. Upper reaches of streams in Sierra de los Organos (western Cuba), Trinidad Mountains (central Cuba) and Sierra Maestra (eastern Cuba).

*2a.*—Present in this habitat.

*3a.*—Entirely confined to this habitat.

*4a.*—Habitat favorable.

*5a.*—Altitudinal range 500 to 1,000 feet. Prefers less turbulent conditions in pools and along the banks, but often found in swift water.

*Toxus serripenis.*

*5b.*—Altitudinal range 100 to 500 feet. Prefers less turbulent conditions in pools and along the banks; seldom found in swift water.

*Toxus creolus.*

*5c.*—Altitudinal range 100 to 500 feet. Prefers less turbulent conditions in pools and along the banks; occasionally found in swift water.

*Glaridichthys uninotatus.*

*3b.*—Partially occurring in this habitat.

*4b.*—Habitat favorable.

*5d.*—Altitudinal range 100 to 1,000 feet. Prefers less turbulent conditions in pools and along the banks; occasionally found in swift water.

*Dactylophallus denticulatus.*

*5e.*—Altitudinal range 100 to 500 feet. Prefers less turbulent conditions in pools and along the banks; seldom found in swift water.

*Girardinus microdactylus.*

*4c.*—Habitat not favorable.

*5f.*—Altitudinal range 100 to 500 feet. Prefers less turbulent conditions in pools and along the banks; seldom found in swift water.

*Allodontium cubense.*

*5g.*—Altitudinal range 100 to 1,000 feet. Prefers less turbulent conditions in pools and along the banks; seldom found in swift water. Absent from the highland habitat in western Cuba.

*Girardinus metallicus.*

*2b.*—Absent in this habitat.

*Glaridichthys falcatus.*

*1b.*—Lowland habitat, usually 5 to 100 feet above sea level. Water usually more or less turbid, warm, not well oxygenated; stagnant or sluggish. Chlorides (Cl) usually 50 to 100 p.p.m., very rarely reaching 1,000 p.p.m. Annual temperature range 25° to 31° C. (mean 28.5). Bottom soft, composed chiefly of mud; sand present; rock, stones and gravel very scarce, usually absent. Aquatic vegetation abundant. Plankton present. Small aquatic insect larvae present. Predators present. Ponds, lakes and lower courses of streams throughout the island of Cuba and the Isle of Pines.

*2c.*—Present in this habitat.

*3c.*—Entirely confined to this habitat.

*4d.*—Habitat favorable.

*5h.*—Altitudinal range 5 to 500 feet; usually below 100 feet. Prefers stagnant water in ponds and lakes.

*Glaridichthys falcatus.*

*3d.*—Partially occurring in this habitat.

*4e.*—Habitat favorable.

*5i.*—Altitudinal range 50 to 100 feet. Prefers stagnant water in lakes.

*Allodontium cubense.*

*5j.*—Altitudinal range 5 to 100 feet. Prefers clear sluggish water in streams.

*Girardinus metallicus.*

*5k.*—Altitudinal range 50 to 100 feet. Prefers streams.

*Dactylophallus denticulatus.*

TABLE 2

ALTITUDINAL DISTRIBUTION AND RELATIVE ABUNDANCE OF THE SPECIES OF THE TRIBE GIRARDININI, EXPRESSED IN NUMBER OF SPECIMENS. ALTITUDINAL ZONES IN FEET (8 COLLECTING STATIONS PER ZONE). DATA BASED ON EXPLORATIONS BY THE AUTHOR

| Species | 5–100 | 100–200 | 200–300 | 300–400 | 400–500 | 500–1000 | Totals |
|---|---|---|---|---|---|---|---|
| *T. serripenis* | | | | | | 23 | 23 |
| *T. creolus* | | 42 | | | 17 | | 59 |
| *G. uninotatus* | | 55 | 26 | | 214 | | 295 |
| *G. falcatus* | 992 | 71 | 203 | 72 | 19 | | 1357 |
| *A. cubense* | 77 | 44 | | | 11 | | 132 |
| *D. denticulatus* | 137 | 140 | 567 | 649 | 81 | 399 | 1973 |
| *G. microdactylus* | | | | | 899 | | 899 |
| *G. metallicus* | 939 | 361 | 757 | 243 | 64 | 47 | 2411 |
| Totals | 2145 | 713 | 1553 | 964 | 1305 | 469 | 7149 |

*4f.*—Habitat not favorable.

*5l.*—Altitudinal range 50 to 100 feet. Occurs only in streams.

*Girardinus microdactylus.*

*2d.*—Absent in this habitat.

*Toxus serripenis, T. creolus, Glaridichthys uninotatus.*

Obviously, the highland and lowland habitats in any given stream are not sharply defined or abruptly separated, but merge into each other, producing transitional zones in which members of either habitat may be found. On the other hand, forms such as *Allodontium cubense, Dactylophallus denticulatus, Girardinus microdactylus,* and *G. metallicus,* which may not be considered as strictly typical of either habitat, seem to favor the intermediate zone or conditions in which a combination of both the highland and lowland are found. The occasional presence (very few individuals) of typical highland forms in the lowland habitat of certain streams during the rainy season is caused by torrents which wash them down. Periodic visits will show gradual disappearance of these forms in the lowland habitat during the dry season and complete absence at the end. Typical highland forms are never found in ponds or lakes, and typical lowland forms (*Glaridichthys falcatus*) are never found in the highland habitat. The following associations may be considered as typical and indicative of clearly defined ecological preferences.

In the lowland habitat of western Cuba, *Glaridichthys falcatus* and *Girardinus metallicus* are the usual components of the girardinin populations with *Glaridichthys falcatus* as the dominant species in ponds and lakes and *Girardinus metallicus* in streams. *Allodontium cubense* occasionally occurs with these, being then intermediate in dominance. The populations of the lowland habitat of central Cuba are typically composed of *Glaridichthys falcatus, Dactylophallus denticulatus,* and *Girardinus metallicus,* with either *Dactylophallus denticulatus* or *Girardinus metallicus* as the dominant species according to prevailing conditions. *Dactylophallus denticulatus* is intermediate and only somewhat more dominant than *Glaridichthys falcatus* when *Girardinus metallicus* is the dominant species. *Glaridichthys falcatus* is intermediate in dominance when *Dactylophallus denticulatus* is the dominant species. The populations of the lowlands of eastern Cuba are composed of *Dactylophallus denticulatus* and *Girardinus metallicus* with *Dactylophallus denticulatus* nearly always as the dominant species. The Isle of Pines has only a lowland habitat and a combination of highland and lowland conditions, with *Glaridichthys falcatus* and *Girardinus microdactylus* as the only members of its girardinin populations.

The highland habitat of western Cuba does not have associations that could be considered as strictly typical. *Toxus creolus, Glaridichthys uninotatus,* and *Girardinus microdactylus* are the usual components of the populations, with *Allodontium cubense* sometimes present and *Glaridichthys uninotatus* always as the dominant species. *Dactylophallus denticulatus* and *Girardinus metallicus* are the only species associated in the highland habitat of central and eastern Cuba, with *G. metallicus* often absent and *Dactylophallus denticulatus* always as the dominant species. In the Rio Guaso and Rio Yateras systems of southeastern Cuba, *Dactylophallus denticulatus denticulatus* is replaced by *D. denticulatus ramsdeni* in the highland habitat, and *Girardinus metallicus* is

absent. *Glaridichthys uninotatus uninotatus* is replaced by *G. uninotatus torralbasi* westward of Rio Guama system in western Cuba.

The transitional zone between the highland and lowland habitat in the southern drainage of the Sierra de los Organos (western Cuba) is by far the richest in genera and species: *Toxus creolus, Allodontium cubense, Glaridichthys uninotatus, G. falcatus,* and *Girardinus metallicus* or *G. microdactylus* sometimes occur together in the same locality. Most of these species are not typical of this habitat where competition seems to be acute and they are represented by few, poorly developed individuals. *Girardinus microdactylus* and *G. metallicus* may occur in the same stream system but are never found together in the same locality.

The only other fishes associated with the tribe Girardinini as possible competitors are the poeciliids *Gambusia* (several species), *Quintana atrizona* and *Limia vittata.* The species of *Gambusia* are all strictly carnivorous, surface feeders and negligible as competitors. *Quintana atrizona* has a very restricted range, and only very few individuals are found sporadically in small ponds of the southern drainage of the Sierra de los Organos and the Isle of Pines. It lives mostly in dense thickets of aquatic vegetation and does not seem to compete with the girardinins. *Limia vittata* is a bottom feeding limnophagous species thriving only in muddy situations. It is widely distributed in Cuba and the Isle of Pines, but its abundance is limited by the nature of the bottom and it is practically absent in the highland habitat. *Gambusia* and *Limia* appear to be relatively recent arrivals from the east (Hispaniola) after the tribe Girardinini was established in the island.

Adaptation and competition are very important factors in girardinin associations, and well-balanced populations seldom consist of more than three genera, each represented by a single species. The degree of dominance of any member of the association is always correlated with, and directly proportional to, its degree of adaptation to and suitability of the habitat. Generalized species such as *Allodontium cubense* are never dominant or strictly restricted to any typical habitat.

In western Cuba, the highland habitat apparently cannot efficiently support more than three species, one of which is usually a generalized form (*Toxus creolus* or *Allodontium cubense*) and the others a "biting feeder" (*Glaridichthys uninotatus*) and a "sucking feeder" (*Girardinus microdactylus*). Generalized and biting feeders are absent from the highland habitat in central and eastern Cuba, where it has been taken over almost exclusively by *Dactylophallus denticulatus* in the absence of competition. This species seems to have originated in a lowland or transitional habitat and its invasion of the highlands of central and eastern Cuba may be considered as relatively recent. The lowland habitat is more favorable and could support a more varied population than it actually does, especially in central and eastern Cuba, and this seems to indicate that girardinin fishes are still in the process of dispersing and invading the lowland habitat which apparently has not as yet, reached the point of saturation.

### ADAPTIVE RADIATION

In the highland habitat, flowing water discourages the formation of slime on rocks, stones, stems, and leaves of aquatic plants. It also discourages but not entirely prevents the deposition of mud and organic detritus and therefore the growth of higher aquatic plants. In the lowland habitat these conditions are exactly the reverse. According to the ecological analysis (pp. 305–307), the food of girardinin fishes consists of diatoms, algae, leaves of the higher aquatic plants, aquatic insect larvae, slime forming on rocks, stones, leaves and stems, and organic detritus contained in the mud.

In the absence of competition, a generalized girardinin (ancestor of the tribe) living in the highland habitat, would not necessarily be compelled to adapt itself to any particular type of feeding, but it would have to become adapted to life in cool, clear, flowing water. This would result in a form having a generalized mouth, body and fins well adapted to life in running water, strong pigmentation, and sensitive to warm, turbid, poorly oxygenated stagnant water. These are exactly the characters of the genus *Toxus* which is the most primitive member of the tribe and must have originated without competition in a highland habitat. This is further confirmed by the paleogeographic and paleoecological evidence and by its present confinement to the highland habitat of western Cuba. Speciation within the genus *Toxus* seems to have occurred more recently through geographical isolation.

On the other hand, a generalized girardinin (ancestor of the tribe) arriving in a vacant transitional habitat of a stream, would tend to adapt itself to the least difficult feeding conditions; that is, ingestion of detritus and organic matter by sucking-in mud or scraping off slime from the

leaves of the higher aquatic plants.[11] No other special adaptation would be required for life in sluggish water and the species would remain relatively generalized, as shown by the monotypic genus *Allodontium*.

Increase of population density brought about by a more favorable habitat in which the two main feeding conditions are relatively abundant, would cause in a generalized form, segregation of individuals (through variation) into incipiently specialized groups, each concentrating in a particular type of feeding. In other words, certain individuals will feed mostly on the slime and mud, others will eat aquatic plants and some will remain generalized in their feeding habits. Owing to preadaptation for feeding by scraping and sucking, a greater percentage of the population will take to this type of feeding and become more rapidly specialized, whereas the generalized feeders will remain as the minority. Speciation will therefore begin, and this adaptive radiation would explain the origin of the genera *Glaridichthys, Dactophallus,* and *Girardinus,* from a common ancestor now represented by the more primitive and generalized *Allodontium cubense*.

Further splitting of the ancestral *Glaridichthys* population by progressive migration and adaptation in opposite directions, resulted in two completely differentiated species with the same feeding characters, but otherwise adapted to life in the highland (*G. uninotatus*) and lowland (*G. falcatus*) habitats respectively. *Dactylophallus* and *Girardinus* are the result of the adaptive trend to feeding by sucking and scraping indicated by their ancestor. *Girardinus* is more specialized for this type of feeding than *Dactylophallus,* and seems to have been derived from the latter. *Dactylophallus* is more primitive, less specialized, and probably evolved before a typical and extensive lowland habitat existed. *Girardinus microdactylus* and *G. metallicus,* like the species of *Glaridichthys,* seem to have recently evolved through adaptation to highland and lowland conditions respectively, and simultaneous geographical isolation.

A very important clue to the interpretation of the early speciational processes undergone by the tribe Girardinini is the discovery of ecological clines in certain eurytopic species, as follows.

As already pointed out, *Dactylophallus denticulatus* may be found in the lowland as well as in the highland zone of the streams throughout its range. In any given stream, individuals from the highland habitat are found to differ from those occurring in the lowland habitat in certain adaptive characters well correlated with ecological conditions. Highland individuals have a smaller mouth, more straight body axis, and more convex predorsal contour longitudinally as well as transversely. In other words, they are better adapted to life in running water and, if isolated from predominating lowland conditions, would eventually develop into a recognizable taxonomic unit. This incipient speciation by adaptive radiation is well illustrated by *Dactylophallus denticulatus ramsdeni*. With the exception of this subspecies, variation between the highland and lowland forms of *D. denticulatus* is small and the intergradation very gradual in each stream and correlated with environmental conditions, thus producing an ecological cline.

In central and eastern Cuba, and on the Isle of Pines, where the typical highland species *Glaridichthys uninotatus* does not occur, *G. falcatus,* in the absence of strong competition has been able to establish itself in transitional habitats. In these habitats, the individuals differ from those occurring in the typical lowland habitat in adaptive characters and have a smaller mouth, more straight body axis, a more convex predorsal contour, and somewhat stronger pigmentation. The incipient adaptive radiation now taking place in *Glaridichthys falcatus* and *Dactylophallus denticulatus* probably is comparable to the early similar process undergone by the ancestral population.

There is no geographical variation of meristic characters in the species of the tribe Girardinini. Phenotypic facies affecting the intensity of coloration vary with localities but they seem to be correlated with periodically varying environmental conditions such as turbidity, and may be purely ecotypic and not geographical in nature. In *Glaridichthys uninotatus torralbasi,* the absence of the black blotch on the sides of the body is correlated with geographical distribution but not with environmental conditions. This subspecies occurs in the same type of habitat (highland streams) as *G. uninotatus uninotatus,* but replaces the latter geographically along the southern and northwestern drainage of the Sierra de los Organos, westward of the Rio Guama system, in western Cuba. Size and body proportions affecting depth

[11] Despite varying degrees of strength found among the various genera, the jaws and teeth of girardinin fishes are essentially weak and adapted to feeding by shaping the mouth into a funnel for the purpose of scraping and/or sucking.

and width seem to be influenced by nutrition and correlated with the fertility of the habitat. Depth and width of body are also greatly affected by pregnancy in females.

As demonstrated for many other fresh-water fishes (Hubbs, 1940: 199) temperature affects the rate of growth in girardinins. Certain populations of *Glaridichthys falcatus, Dactylophallus denticulatus,* and *Girardinus metallicus* living in thermal springs, grow faster and have proportionately larger heads and head parts. In general, highland species living in cooler water have smaller heads than the lowland warmer water species. Meristic characters are not affected by temperature and show little or no variation within each species.

It is evident that girardinin fishes are very "plastic" to the environment and that speciation within the tribe has been the result of adaptive radiation induced by feeding conditions in combination with other physical characters of the habitat, competition, and geographical isolation.

### CENTER OF ORIGIN

The distributional pattern of the tribe Girardinini (fig. 11 and table 3) shows at a glance that the genera and species are most numerous in western Cuba throughout the southern drainage of the Sierra de los Organos, and much less numerous to absent in eastern Cuba. With the exception of *Dactylophallus denticulatus,* all the genera and species occur in western Cuba whereas not more than three genera and species occur outside that region. There are four genera and seven species in the western fourth of the island, and only two genera and two species in the eastern fourth. Central Cuba has three genera and three species, and there are only two genera and two species on the Isle of Pines. The number of genera and species decreases to the east from the area of greater abundance, and the ranges of the more advanced forms (*Dactylophallus, Girardinus*) are peripheral to those of the more primitive (*Toxus, Allodontium*).

The above pattern of distribution and the assumed arrival of the ancestor from the west, would seem to indicate that western Cuba was the center of origin of the tribe, but other factors must be analyzed and correlated before any conclusions can be reached.

The ancestor of the tribe Girardinini is assumed to have arrived in western Cuba directly from the west (Central America) by way of the land connection postulated earlier in this paper. According to the paleogeographic evidence (p. 313), the western portion comprising the nucleus of the Sierra de los Organos was isolated as an island from the rest of Cuba for a long time after arrival of the ancestral population, and the first girardinin form evolved must have been the more primitive genus *Toxus,* as shown elsewhere in this study. The species of *Toxus* are strictly mountain stream forms confined to the highlands of the southern drainage of the Sierra de los Organos and could not have originated in a lowland habitat. The only other habitats suitable for *Toxus* have existed only in central (Trinidad Mountains) and eastern (Sierra Maestra) Cuba, and according to the paleogeographic evidence (p. 313) these mountain masses and the Sierra de los Organos have always been separated by shallow seas or extensive lowlands. Former occurrence and subsequent elimination of *Toxus* to the east of its present range through extinction by predator pressure or competition does not seem to have been possible for the following reasons.

TABLE 3

GEOGRAPHICAL DISTRIBUTION OF THE FISHES OF THE TRIBE GIRARDININI BY PROVINCES, SHOWING THE GREATER ABUNDANCE OF GENERA AND SPECIES IN WESTERN CUBA (See footnote 12). Although belonging politically to the Province of Habana, the Isle of Pines is here included with the Province of Pinar del Rio for geographical reasons.

| Species | P. del Rio | Habana | Matanzas | Las Villas | Camaguey | Oriente |
|---|---|---|---|---|---|---|
| *T. serripenis* | * | | | | | |
| *T. creolus* | * | | | | | |
| *G. uninotatus* | * | | | | | |
| *G. falcatus* | * | * | * | * | * | * |
| *A. cubense* | * | | | | | |
| *D. denticulatus* | | | | * | * | * |
| *G. microdactylus* | * | | | | | |
| *G. metallicus* | * | * | * | * | * | * |

The only fishes permanently or periodically occurring in the fresh waters of Cuba known to prey on girardinin fishes are: *Atractosteus tristoechus* (Lepisosteidae), *Megalops atlanticus* (Elopidae), *Anguilla bostoniensis* (Anguillidae), *Centropomus* spp. (Centropomidae), *Cichlasoma tetracanthus* (Cichlidae), *Phylipnus dormitor, Eleotris pisonis* and *Dormitator maculatus* (Eleotridae). With the exception of *Atractosteus* which is confined to the southern drainage of western Cuba, these predators are equally distributed throughout the entire range of the tribe Girardinini. *Atractosteus* and *Cichlasoma* are the most effective predators and entirely confined to fresh water. The fossil record shows that *Atractosteus* has existed in the island since the Cretaceous and *Cichlasoma* probably since the Miocene. The other species are marine or semimarine and ascend streams only during certain periods of the year (*Anguilla*) or not far above the tidal zone. It is therefore evident that, as far as the tribe Girardinini is concerned, predator pressure is, and has always been, more active in western Cuba. Competition is also much more active in western Cuba owing to the greater number of genera and species occurring in that region. The mountain range itself, inability to survive in the lowlands and competition seem to have been the barriers preventing further extension of range in *Toxus*.

Further proof that the genus *Toxus* has not formerly occupied a much greater range than it does at present, is its absence from the Isle of Pines. This relatively large island (1,200 square miles) lies to the southeast of the southern drainage of the Sierra de los Organos, from which it is separated by about 27 nautical miles of very shallow sea. The Isle of Pines has been periodically connected with western Cuba during the Pleistocene, and was permanently isolated last as an island in relatively recent times.

It is also very improbable that the primitive genus *Toxus*, a true, or at the most a slightly modified relict of the ancestral girardinin population, could have originated to the east far from where it now occurs, and remained the most unspecialized member of the tribe, after dispersal through a variety of markedly distinct habitats.

Since *Toxus* is the most primitive and first evolved member of the tribe, no further explanation involving other species seems necessary in order to show that the southern drainage of the Sierra de los Organos was the center of origin and early dispersal of the group. A western location of the center of origin and direct arrival from the west of the ancestral population are not, in my opinion, mere coincidence, but correlated, reciprocal proof that the theories relating to the matter postulated in this paper, must not be far from reality.

## 4. THE MECHANISMS OF SPECIATION AND DISPERSAL LEADING TO THE PRESENT FORMS WITHIN THE TRIBE AND THEIR GEOGRAPHICAL DISTRIBUTION ARE EXPLAINED BY THE PALEOGEOGRAPHY AND PALEOECOLOGY OF THE ISLAND OF CUBA

### PALEOGEOGRAPHY AND PALEOECOLOGY

According to the paleogeographic evidence (Schuchert, 1935; Massip, 1942), the present structure of Cuba was established during the Miocene-Pliocene simultaneously with the Yucatan isthmian link (see p. 303 and fig. 9) and as the result of the same orogenic forces. Speciation and dispersal in the tribe Girardinini began when the ancestor became established in western Cuba at the end of the Pliocene, and were induced by the environmental and physiographic changes produced by the Glacial periods during the Pleistocene (Daly, 1934; Flint, 1947). The island of Cuba is situated between 19° 50′ and 23° 20′ lat. N, just below the Tropic of Cancer and has never been under the direct influence of glaciation. However, changes of temperature, pluviosity, sea level, and the accompanying subaerial and marine erosion, have greatly affected the physiography and ecology of the island during the Pleistocene.

During the Glacial stages of the Pleistocene, general lowering of the sea level must have reached about sixty fathoms below the present level (Daly, 1934; Flint, 1947), and the island of Cuba was then wholly emergent with a coastline corresponding with the present edge of the insular shelf (see fig. 12 (1C)). The stream systems and lowlands were then much more extensive than today and some existed that are now entirely submerged (Massip, 1942: 177–180). Many of the now isolated stream systems of Cuba, especially those of the southern drainage, were consequent tributaries of subsequent main streams during the periods of greatest emergence. These streams are now dismembered as separate, less extensive systems through partial or total submergence of lower course of the main stream by recent rein-

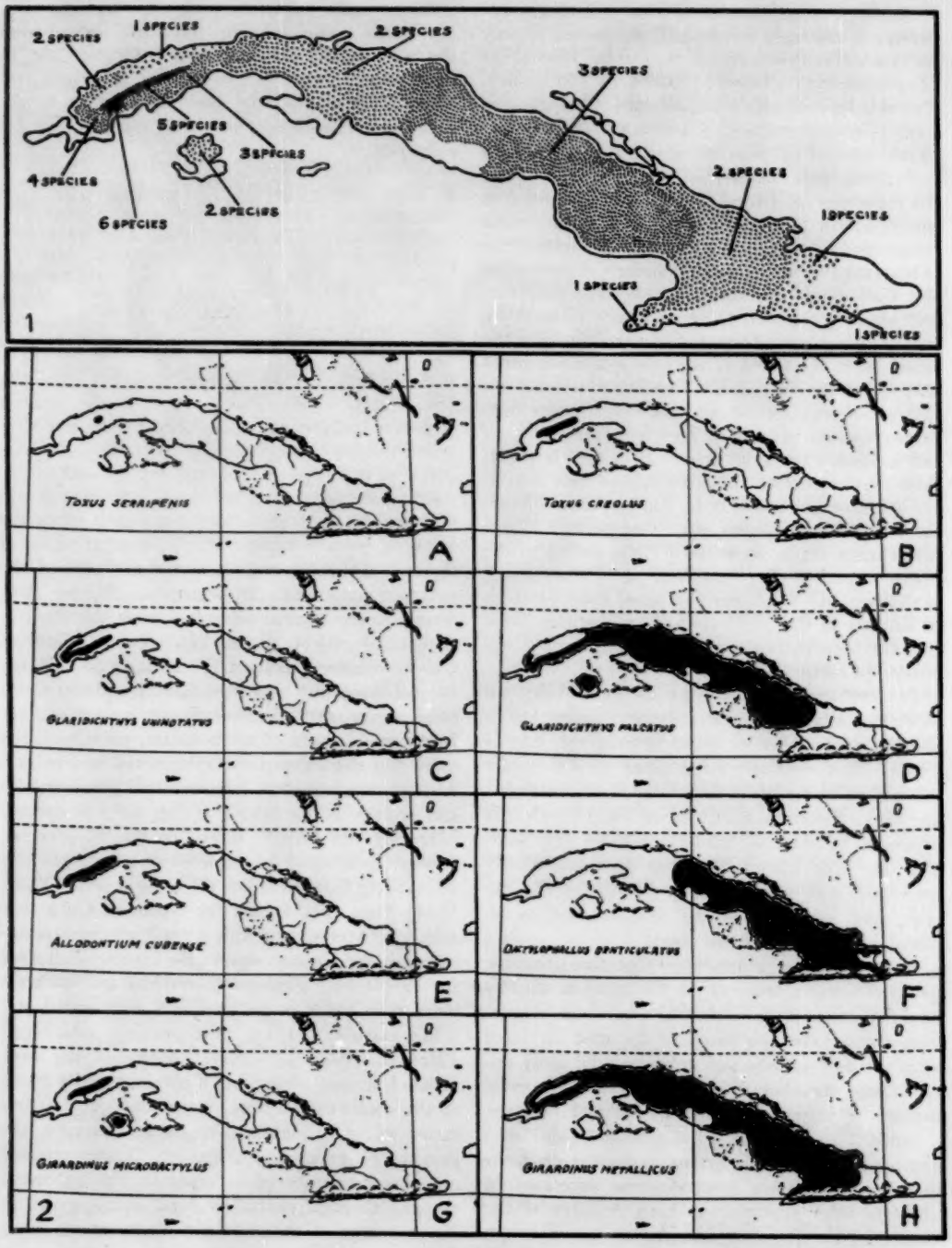
2 SPECIES
1 SPECIES
2 SPECIES
3 SPECIES
5 SPECIES
3 SPECIES
4 SPECIES
2 SPECIES
6 SPECIES
2 SPECIES
1 SPECIES
1 SPECIES
1 SPECIES
1
TOXUS SERRIPENIS
A
TOXUS CREOLUS
B
GLARIDICHTHYS UNIMOTATUS
C
GLARIDICHTHYS FALCATUS
D
ALLODONTIUM CUBENSE
E
ORTHOPHALLUS DENTICULATUS
F
GIRARDINUS MICRODACTYLUS
G
2
GIRARDINUS METALLICUS
H

FIG. 11.

vasion of the sea. The Rio Cauto [12] of the southwestern drainage of the Province of Oriente (eastern Cuba) is now about 130 miles long and empties into the shallow Gulf of Guacanayabo, but during the periods of greatest emergence, it flowed westward over the emerged insular platform, was about 200 miles long, and received the now dismembered Jobabo, Sevilla, and Najasa of the southern drainage of the Province of Camaguey, as tributaries (Massip, 1942: 178). During the interglacial periods of greatest submergence (Massip, 1942: 151), Rio Cauto was only about 50 miles long and most of its present tributaries were dismembered (fig. 12 (1A)). Rio San Pedro, Rio Hatiguanico, and many other streams, have gone through similar cycles and the now entirely submerged river which flowed to the southwest between the Province of Pinar del Rio and the Isle of Pines, had as tributaries all the present streams of the southern drainage of the Sierra de los Organos (Massip, 1942: 178, 179).

There are at present about 150 stream systems in each drainage of Cuba. Those of the southern drainage of the Province of Oriente, between Cape Cruz and Santiago Bay are very short, steep, and torrential and do not contain poeciliid fishes, with the exception of Rio Portillo. There are 96 stream systems in the southern drainage west of Cape Cruz, but during the periods of greatest emergence there were only 14, some of them (Cauto, San Pedro, Hatiguanico) very extensive. Since most of the Cuban streams were dismembered very recently by submergence of the platform and parts of the coastal plain, after the last (Wisconsin) Glacial stage, their girardinin populations accordingly do not show the effect of geographical isolation. Besides, the main types of habitat are essentially the same in each stream, and there is frequent communication between many of them by flooding of the lowlands.

[12] For further and more detailed information on the hydrography and general physiography of Cuba, the following sources may be consulted: Massip, 1942, U. S. Navy Hydrographic Office chart No. 2145, National Geographic Society map of the West Indies, 1954.

FIG. 11. (1) Distributional density of the tribe Girardinini. Blank areas represent mountainous regions or marginal brackish water coastal zones where girardinin fishes do not occur. (See also fig. 9 (4), 12 (2).) (2) Geographical distribution of the species of the tribe Girardinini. A, *Toxus serripenis*. B, *Toxus creolus*. C, *Glaridichthys uninotatus*. D, *Glaridichthys falcatus*. E, *Allodontium cubense*. F, *Dactylophallus denticulatus*. G, *Girardinus microdactylus*. H, *Girardinus metallicus*.

During the interglacial stages, submergence of the platform and marine invasion of the lowlands turned the highlands of western, central, and eastern Cuba into isolated islands (fig. 12 (1A)), and the great river systems of the glacial stages were drowned or greatly dismembered. All during the Pleistocene, Cuba was being gradually uplifted and every successive interglacial marine invasion left greater portions of these islands emerged. Continued subaerial and marine erosion were also making the lowlands more extensive and the highland habitat more accessible, especially throughout the southern drainage of the island.

### MECHANISMS OF SPECIATION AND DISPERSAL

When the ancestral population of the tribe Girardinini had become established in western Cuba during the Pliocene, this region was still separated from the emerged portions of central and eastern Cuba by shallow seas which prevented further dispersal to the east (fig. 13 (1)). At the same time, western Cuba was permanently separated from Central America and the ancestral population was isolated and must have then developed its tribal characters (fig. 6). During that time, the emerged land of western Cuba formed a high, narrow, elongate island (Sierra de los Organos) with typical mountain streams and little or no lowland habitat. The northern slope of this island was much narrower and steeper than the southern, and its streams must have been too fast and torrential to maintain a poeciliid population. The ancestral girardinin species must have been therefore, a highland form confined to the southern drainage of the Sierra de los Organos island. This is confirmed by the structure, behavior, ecology, origin, and distribution of *Toxus*, the most primitive genus of the tribe, as already discussed.

Gradual uplift and continued subaerial and marine erosion during the late Pliocene combined with a general lowering of sea level during the first glacial stage (Nebraskan) of the Pleistocene, produced a general emergence of the shallow, submerged banks. Extensive plains were thus created and the western portion of Cuba was joined with the rest of the island and the Isle of Pines (fig. 13 (2)). The streams of the southern drainage of the Sierra de los Organos became less rapid as the divide was lowered producing a less steep slope. As the coastal (piedmont) plain gradually emerged and widened, the streams lengthened their courses and a lowland habitat was

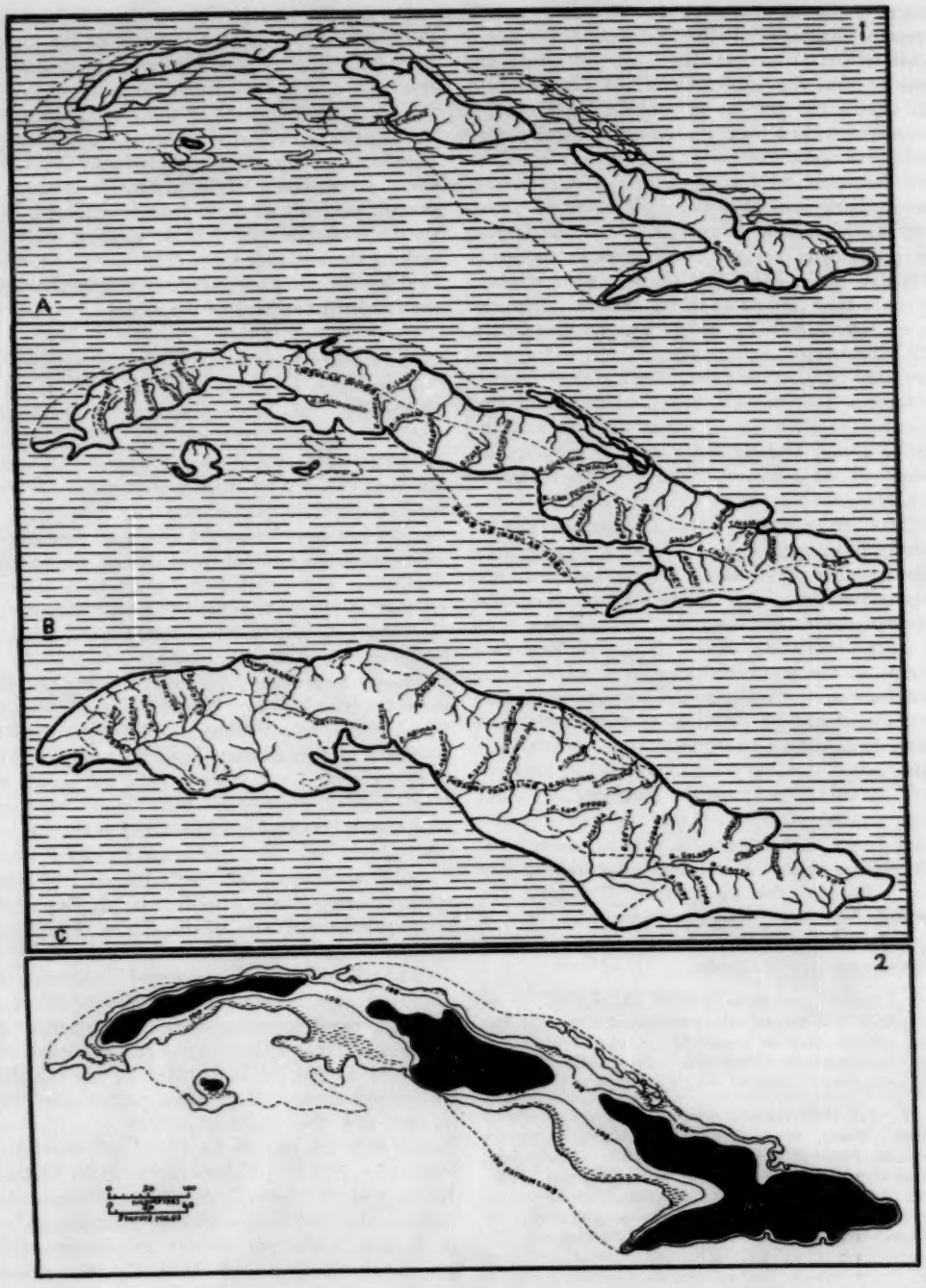


FIG. 12.

created. This period marks the origin of the most important stream systems of the southern drainage of the Sierra de los Organos, such as the Cuyaguateje, Guama, San Diego, Los Palacios, and San Cristobal (see footnote 12). These streams are characterized by a comparatively short and steep mountain course, an even shorter transitional zone and a much longer lowland course on the coastal plain. For example, the upper reaches of Rio San Cristobal flow a distance of about 8 miles before entering the coastal plain which is about 15 miles wide throughout the rest of its course. The transitional zone covers a distance of about 3 miles (Schuchert, 1935: fig. 80).

When the south coastal plain emerged in western Cuba and a lowland habitat began to form, part of the highland ancestral population gradually filled the newly created environment. Preadaptation to life under these more favorable conditions, must have very rapidly produced an ecological cline in every stream, consisting of a lowland race or subspecies gradually intergrading with the highland form. In the absence of competition and highland habitats, dispersal to the east through lowland streams over relatively extensive plains must have finally isolated the lowland from the highland subspecies and full speciation was achieved. The highland subspecies remained in its original habitat and through little transformation evolved into the genus *Toxus* (fig. 6). The lowland subspecies became adapted to lowland conditions and in the absence of competition evolved into a species which remained relatively generalized in its feeding structures and behavior. This species is assumed to have been the ancestor of the genera *Glaridichthys, Dactylophallus,* and *Girardinus,* and now remains slightly transformed as *Allodontium cubense* (fig. 6).

During the first Glacial stage (Nebraskan) of total emergence, the ancestral *Allodontium* continued its dispersal to the east and by the end of the period it had invaded the lowlands of the western half of the island (fig. 13 (2)). In the absence of species competition, increase of population density in the rich, varied lowland habitat must have caused individual competition and initiated adaptive radiation in the generalized ancestral *Allodontium.* This incipient speciation marks the origin of *Glaridichthys* and *Dactylophallus* in central Cuba (figs. 6; 13 (3)).

The following interglacial period (Aftonian) produced a partial submergence of Cuba and the evolving ancestral *Allodontium* was isolated in the island formed by the Trinidad Mountains and the plateau of central Cuba. In this region, a considerable amount of transitional habitat remained emerged and its initial invasion by incipiently adapted forms must have produced ecological clines and further adaptive radiation. On the other hand, during this interglacial period, Sierra de los Organos remained as a mountainous island and the lowland habitat of western Cuba and its population were entirely eliminated by the rapid submergence of the piedmont plain, including the Isle of Pines (fig. 13 (3)).

The second Glacial stage (Kansan) produced again total emergence of the island of Cuba and its platform and the already heterogeneous (*Glaridichthys, Allodontium, Dactylophallus*) population of central Cuba began to disperse towards the east and west. At the end of the period, it probably had invaded most of the island except the highland habitats (fig. 13 (4)). However, only the most aggressive and better adapted ancestral *Dactylophallus* must have been able to reach eastern Cuba.

During the second interglacial period (Yarmouth), partial submergence of Cuba isolated part of the ancestral *Dactylophallus* population in the eastern portion where it evolved into *D. denticulatus* (fig. 6) and the ancestral *Glaridichthys, Allodontium,* and *Dactylophallus* (part) remained isolated in central Cuba (fig. 14 (5)). Western Cuba was probably cut off before these species could reach that region.

The third Glacial stage (Illinoian) marks another period of total emergence during which further dispersal over the lowlands takes place (fig. 14 (6)). *Dactylophallus denticulatus* gradually dispersed towards the west but did not reach central Cuba before the third interglacial stage (Sangamon) marine invasion isolated the eastern from the central portion for the third time. During the third Glacial stage, a more extensive and typical lowland habitat (now represented by the Zapata Swamp and the Colon Plain) was formed to the west of central Cuba and dispersal

FIG. 12. (1) Pleistocene hydrography of the island of Cuba during the Glacial stages. A, interglacial stages (Aftonian, Yarmouth, Sangamon). B, present hydrography. C, glacial stages (Nebraskan, Kansan, Illinoian, Wisconsin). (2) Present distribution of highlands in the island of Cuba. Solid black areas indicate regions 250 feet or more above sea level, which were never submerged during the Pleistocene. The thin line represents the 100 foot contour, and the dotted line the edge of the insular shelf.

from the central plateau must have taken place much more rapidly in that direction. The ancestral *Dactylophallus* population which had been isolated in central Cuba during the second Glacial stage, became further adapted to typical lowland conditions and evolved into *Girardinus* (figs. 6; 14 (5)) in the lowlands. *Girardinus*, being more aggressive and better adapted to lowland condi-

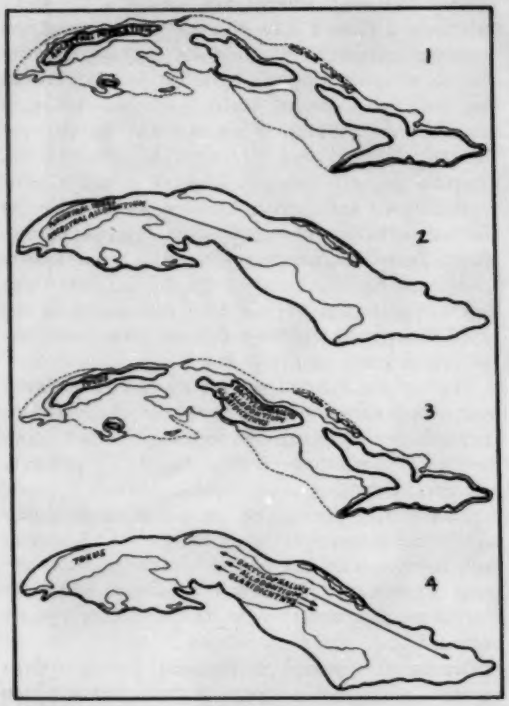


FIG. 13. Speciation and dispersal in the tribe Girardinini (continued on fig. 14). The thin line represents the present coast line, the heavy line represents the coast line during the designated glacial and interglacial stages, and the dotted line indicates the present edge of the insular shelf. Arrows indicate the direction and extent of dispersals. (1) The ancestral population is isolated during the Pliocene (Preglacial) in western Cuba, where it acquires its tribal characters. (2) The ancestral *Allodontium* disperses to the east and invades the lowlands of the western half of the island during the first glacial stage (Nebraskan). The ancestral *Toxus* remains confined to the highlands of western Cuba. (3) The ancestral *Allodontium* is isolated in central Cuba during the first interglacial stage (Aftonian), and gives rise to *Glaridichthys* and *Dactophallus*. (4) During the second glacial stage (Kansan), the population composed of *Allodontium*, *Glaridichthys*, and *Dactylophallus* disperses to the east and west, but only *Dactylophallus* reaches the eastern portion of the island. *Toxus* remains confined to the highlands of western Cuba.

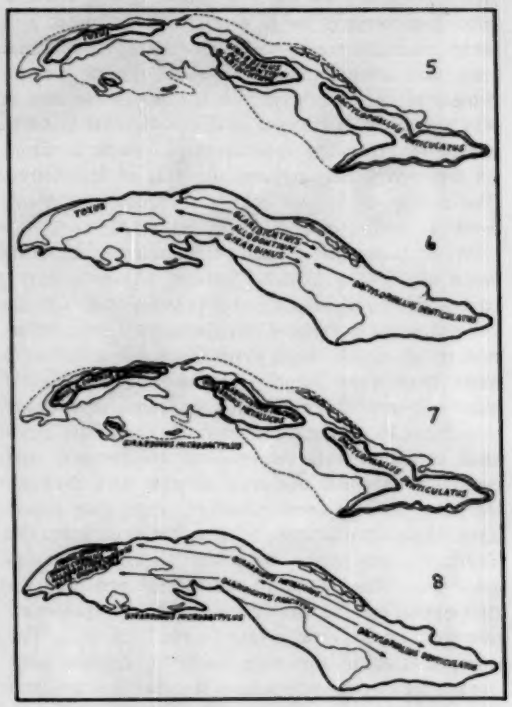


FIG. 14. Speciation and dispersal in the tribe Girardinini (continued from fig. 13). (5) *Allodontium* and *Glaridichthys* remain confined to central Cuba during the second interglacial stage (Yarmouth). The ancestral *Dactylophallus* population in central Cuba evolves into *Girardinus* and that in eastern Cuba into *Dactylophallus denticulatus*. (6) Further dispersal takes place during the third glacial stage (Illinoian). *Dactylophallus denticulatus* disperses toward the west, and *Allodontium*, *Glaridichthys*, and *Girardinus* disperse to the east and west. *Toxus* remains confined to the highlands of western Cuba. (7) During the third interglacial stage (Sangamon), the *Allodontium* and ancestral *Glaridichthys* populations evolve into *Allodontium cubense* and *Glaridichthys uninotatus* respectively in western Cuba, and *Girardinus* evolves into *G. microdactylus* on the Isle of Pines and *G. metallicus* in central Cuba. The ancestral *Glaridichthys* population in central Cuba evolves into *G. falcatus*. *Toxus* remains confined to the highlands of western Cuba and *Dactylophallus denticulatus* to eastern Cuba. (8) Speciation is completed and during the fourth glacial stage (Wisconsin), final dispersal results in the present distribution of the members of the tribe. (See fig. 11.)

tions, was probably able to disperse faster and further to the west than *Allodontium* and *Glaridichthys*. Consequently, when the Isle of Pines was cut off during the third interglacial stage, *Girardinus* was probably the only form isolated on that island. *Allodontium* and *Glaridichthys*, however, had managed to reach the piedmont plain of the southern drainage of the Sierra de los Organos but not the Isle of Pines.

During the third interglacial stage (Sangamon), when the sea submerged again the lowland habitat of western Cuba, the *Girardinus* population must have been entirely eliminated but *Glaridichthys* and the generalized *Allodontium* were probably able to survive in the remaining transitional habitat (fig. 14 (7)). The *Glaridichthys* population isolated in the southern drainage of the Sierra de los Organos became adapted to highland conditions and evolved into *G. uninotatus*, but *Allodontium*, unable to compete with *Toxus*, must have remained unchanged in the transitional habitat. The *Glaridichthys* and *Girardinus* populations, isolated in the extensive, emerged lowlands of central Cuba, evolved into *Glaridichthys falcatus* and *Girardinus metallicus*. The small *Girardinus* population isolated in a transitional habitat in the emerged central portion of the Isle of Pines, must have very rapidly evolved ("Sewall Wright effect," Huxley, 1942: 59) into *G. microdactylus* in the absence of competition.

Speciation in the tribe Girardinini was therefore probably completed at the end of the third interglacial stage (figs. 6; 14 (7)). During the fourth and last Glacial stage (Wisconsin), final total emergence of the Island of Cuba brought about the final dispersal which resulted in the present distribution of the members of the tribe (figs. 14 (8); 11). *Toxus* has remained in the highlands of the southern drainage of the Sierra de los Organos since its origin there in the late Pliocene, and this long isolation is well confirmed by its taxonomic relationships. *Allodontium cubense* is considered a relict of the once more widely ranging generalized ancestor of *Glaridichthys*, *Dactylophallus*, and *Girardinus*. It is now confined to the southern drainage of the Sierra de los Organos and seems to be gradually becoming extinct through competition. *Glaridichthys uninotatus* remains in the highland habitat of western Cuba, but *G. falcatus*, as would be expected, has invaded most of the lowlands of Cuba and the Isle of Pines. *Dactylophallus denticulatus* has reached central Cuba and seems to be actually in the process of dispersing further to the west. *Girardinus metallicus*, from its center of origin in central Cuba, has rapidly invaded all the lowland habitats of Cuba, but competition with *G. microdactylus* prevented its establishment in the Isle of Pines when that island was still connected with western Cuba during the last Glacial stage. *G. microdactylus*, however, reached the nearby southern drainage of the Sierra de los Organos before *G. metallicus* had arrived in western Cuba. Since the peak of the now receding last Glacial stage, marine reinvasion of the platform has very recently separated again the Isle of Pines from the mainland of Cuba. The *Glaridichthys falcatus* and *Girardinus microdactylus* populations now isolated in the Isle of Pines show little divergence from those of the same species in the mainland of Cuba.

The much greater extent of the lowland habitat and the more rapid and frequent means of dispersal afforded by floods have probably permitted a much wider occurrence of typical lowland forms such as *Glaridichthys falcatus* and *Girardinus metallicus*. Lowland conditions, however, have probably prevented further dispersal of typical highland forms.

In the tribe Girardinini, extent of range is generally correlated with age and habitat. The more primitive species have smaller ranges and are adapted to highland conditions, whereas the more recent species have more extensive ranges and are adapted to lowland conditions. This is opposed to the principle of "age and area" proposed by Willis (1922), and appears to be the result of the physiographic and environmental evolution of the island of Cuba during the Pleistocene. The ecological analysis has shown that despite the more favorable conditions found in the lowlands, a greater number of species occurs in the highland and transitional habitats. This indicates that speciation in the tribe Girardinini must have taken place mostly in these habitats, since according to the paleogeographic evidence, lowland conditions have been periodically absent during the evolutionary period of the group.

According to the evidence presented in this study and the geological time tables (Flint, 1947), the ancestral population of the tribe Girardinini became established and acquired its tribal characters in western Cuba at the end of the Pliocene, The genus *Toxus* was the first form evolved at that time, and *Allodontium* and the ancestral *Glaridichthys* and *Dactylophallus* evolved during

the first Glacial stage. *Dactylophallus denticulatus* and *Girardinus* evolved during the second interglacial period. *Glaridichthys uninotatus, G. falcatus, Girardinus microdactylus,* and *G. metallicus* evolved during the third interglacial stage. Girardinin fishes are conservatively estimated to produce about six to eight generations per year, and over ten million generations must have been required for the evolution of the present five genera and eight species. The rate of speciation in the tribe Girardinini has probably been modified by ecological conditions, duration of isolation and population size, and the time required for generic and specific differentiation has varied according to these factors in the various forms. The rate of dispersal among the most widely ranging members of the tribe must have involved distances of 1,000 to 2,000 miles during the greater part of a million years. These figures are not inconsistent with the estimated rate of dispersal of *Astyanax fasciatus* through Central America and Mexico during the Pleistocene (Schaeffer, 1952: 228).

## SUMMARY

The extensive amount of material and information on the taxonomy, and general biology of the Cuban poeciliid fishes of the tribe Girardinini accumulated by the author during a period of eighteen years, has resulted in the present study dealing with their origin, phylogeny, speciation, dispersal, and geographical distribution. A theory expressing the author's views in connection with these matters is given in four postulates, whose development forms the main body of this study.

The tribe Girardinini is confined to the fresh waters of the island of Cuba, and comprises five genera and eight species (*Toxus serripenis, T. creolus, Glaridichthys uninotatus, G. falcatus, Allodontium cubense, Dactylophallus denticulatus, Girardinus microdactylus,* and *G. metallicus*). Generic differentiation is mostly based on gonopodial and mouth characters, especially the latter.

The phylogeny of the tribe is based on ontogenetic studies and a taxonomic analysis of its members in which interrelationships and phyletic lines are established. The taxonomic analysis is conducted on the basis of sexual, adult non-sexual, and juvenile characters. These three methods of approach indicate independently that relationships remain the same within the tribe, regardless of the method of analysis employed, and the taxonomic criteria for generic and specific distinction must be valid. Two primary (represented by *Toxus* and *Allodontium*) and two secondary (represented by *Glaridichthys* and *Dactylophallus-Girardinus*) phyletic lines are found to lead to a single common ancestor. *Glaridichthys and Girardinus* are found to be the present end points of two diverging, adaptive evolutionary trends, derived through *Allodontium* from the less advanced, primary phyletic line represented by the more primitive genus *Toxus*.

The relationships of the group with *Allogambusia* of Panama and *Phalloceros* of Brazil, upon comparison with all the other members of the family Poeciliidae, indicate that the common ancestor of the tribe probably came from Central America. This is in agreement with a similar origin postulated for most of the fauna of Cuba, as found by all other students of West Indian zoology, but opinions are divided as to the manner fresh-water fishes and many other organisms reached the island. Some favor dispersal by means of a land connection, and others over water dispersal across narrow straits by swimming, flotsam or jetsam, or through the air, by means of cyclonic storms.

The ecology and distribution of the tribe Girardinini shows that the group is confined to fresh water and that it has preference for highland streams. Experiments have demonstrated that the species cannot survive in salt, or even brackish water. They are also sensitive to pressure and always occur in shallow water not far from the shore, and seldom at the surface. These ecological features are used to demonstrate that girardinin fishes could not have crossed salt water gaps by swimming. Over-water dispersal through the air is also thoroughly discussed in the light of ecological and distributional evidence, and found not to have been the manner thereby the ancestor of the tribe reached Cuba. Dispersal by birds, flotsam and jetsam, is discussed and dismissed as impossible in girardinin fishes.

It is assumed that, if the ancestor of the tribe Girardinini did not reach the island of Cuba by over-water dispersal or by swimming across a water gap, then it must have migrated through fresh water by means of a land connection between Central America and Cuba. The relationships, location of the center of origin in western Cuba, and the absence of near relatives of the group in the Caribbean area except Central America indicate that the ancestor of the tribe must have migrated directly from Central America, by means of a land connection between Yucatan and western

Cuba during the Miocene-Pliocene. This is in agreement with the available evidence, and a discussion on the possibility of such a connection is offered and based on geologic, paleogeographical, and physiographical data. Objections to the former existence of a land connection between Central America and Cuba based on the absence of certain Central American organisms on the island are discussed and rejected.

The morphology of the members of the tribe Girardinini indicates that speciation in the group has occurred through adaptive radiation involving chiefly feeding habits. This is discussed and confirmed by an ecological analysis of the tribe, in which structure and behavior are correlated with habitat and occurrence. Ecological preferences, competition, and dominance are also discussed by analysis of girardinin populations and study of genera and species associations. The lowland habitat is found to be more favorable and potentially able to support a more varied population than it actually does. This indicates that it probably has not reached yet the saturation point. Occurrence of a greater number of forms in the highland habitat indicates that speciation has probably mostly taken place under those conditions and that the lowland habitat has been periodically eliminated and exists at present only since relatively recent times. A very important factor in the speciation of girardinin fishes has been the existence of ecological clines producing adaptive radiation in populations. There is no geographical variation of meristic characters in the species of the tribe Girardinini, and phenotypic facies affecting certain characters are correlated with periodically varying environmental conditions, and not geographical in nature.

The center of origin of the tribe is found to have been located probably in western Cuba, since *Toxus*, the most primitive and first evolved member of the group is demonstrated to have originated in that region. This is accomplished by correlating the western arrival of the ancestor and the habitat and distribution of *Toxus* with the paleogeography of Cuba and an analysis of dispersal factors.

The mechanisms of speciation and dispersal leading to the present genera and species and their geographical distribution are discussed by correlating phylogeny, adaptation, and geographical distribution with the paleogeography and paleoecology of Cuba. Speciation in the tribe Girardinini began when the ancestral population became established in the island of Cuba at the end of the Pliocene, and took place during the Pleistocene. Speciation and dispersal in the group were induced by the environmental and physiographic changes produced by the Glacial periods of the Pleistocene. Changes of sea level and subaerial and marine erosion caused great periodic changes in the hydrography of the island and a complete, periodical isolation of its western, central, and eastern portions into three separate smaller islands. Speciation probably was completed at the end of the third interglacial stage, and the present geographical distribution was recently attained after the peak of the fourth and last Glacial stage.

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